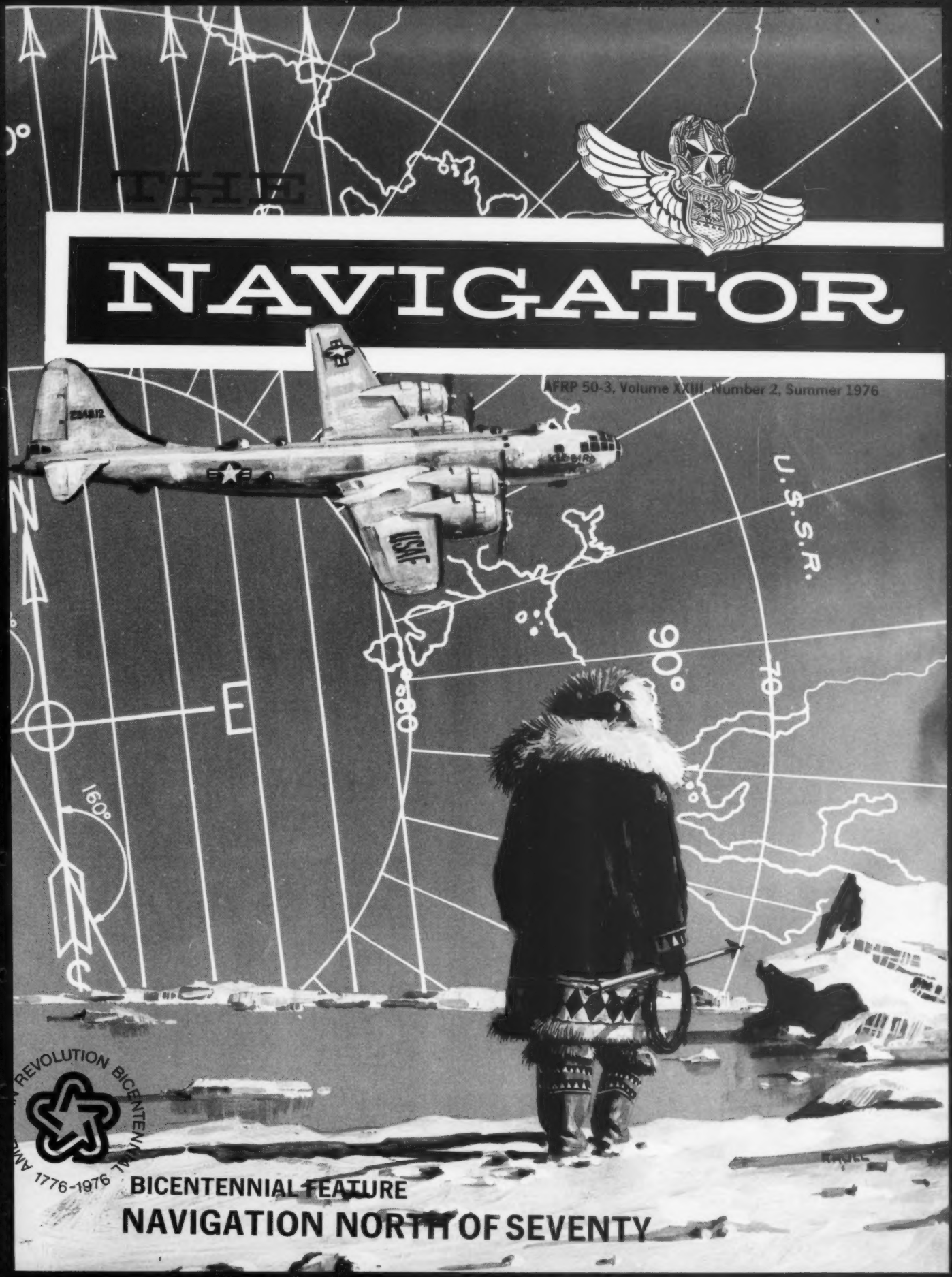
NAVIGATOR
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USAF
AMERICAN REVOLUTION BICENTENNIAL
1776-1976
BICENTENNIAL FEATURE
NAVIGATION NORTH OF SEVENTY

NAV OF NOTE

Colonel Thomas J. Lapos is the Director of Instruction of the Defense Race Relations Institute at Patrick AFB, Florida. In this capacity he is the senior Air Force member on the DRRI staff, the direct supervisor of military personnel assigned from the Army, Navy, Air Force and Coast Guard, and responsible for all the DRRI curriculum at this unique school.

He was born and raised in Lansford, Pennsylvania, a hard coal region of the state. Upon graduation from high school in 1949 he went to work for Sears, Roebuck and Company. During 1951, when the threats of the Korean War hung heavily over the world, Tom Lapos enlisted in the USAF. Lackland AFB, Texas, was his first stop for processing and some basic training, then Sheppard AFB, Texas, for the remainder of basic. Graduation from basic training resulted in a stripe and entry into the Aircraft and Engine (A/E) Mechanic school at Sheppard.

From Sheppard he went to Chanute AFB, Illinois, for Flight Engineer training. While at Chanute he was selected for the Single Observer Flying program via Aviation Cadets. The 52-week Aviation Cadet program was tough but very rewarding for Cadet Lapos. It terminated in March 1953 with a commission as a Second Lieutenant. The awarding of his Silver Observer wings occurred at Mather AFB, California, during April 1953.

Lieutenant Lapos was then off to Langley AFB, Virginia, for B-26 Combat Crew Training and a TDY to Stead AFB, Nevada, for survival training enroute to Korea. During August 1953, while on an Escape and Evasion Survival Exercise with his combat ready crew, the war ended in Korea. At this point a hold was placed on PCS transfer action to Korea. During this period the opportunity presented itself for Lieutenant Lapos to marry his cadet sweetheart, the former Freeda Joan Beckwith.

During September 1953, Tom Lapos and his new bride were reassigned to Ellington AFB, Texas, for his duties as a navigation instructor. This was a unique experience, as he taught a special course designed to train B-47 pilots for a dual rating as navigators. He remained in this program through 1957 and from there was off to Chanute AFB, Illinois, for training as a Maintenance Officer. His next major assignment was as a navigator with C-130s in Germany on a special mission. This assignment was varied as he had an opportunity to function as a Crew Navigator, Squadron Maintenance Officer, and as a Detachment Commander at Incirlik, Turkey. It also offered the opportunity to attend an Intelligence Officers Course in Oberammergau, Germany.

In 1962, he was reassigned to Sewart AFB, Tennessee for duty with the newly formed 4442nd Combat Crew Training Group, mission: C-130 Combat Crew Training. Again, a dynamite assignment—Hq Squadron Commander to Chief of Plans and Programs scheduling a fleet of C-130A, B's and E's; working simulator schedules, coordinating maintenance schedules, and assisting in the scheduling of instructor pilots and instructor flight engineers. Also, "Captain Lapos" was a Chief Flight Test Navigator for the school. As an interlude to his flying career, Tom Lapos attended the Air Command and Staff College (ACSC) 1965-66. Promoted to Major while at ACSC, he was reassigned to the 21st Tactical Airlift Squadron at Naha Air Base, Okinawa. While with the 21st he flew special missions, spent time in Vietnam, and was assigned as Chief Navigator. From Naha he went to instructor duties at Mather AFB, California. This, for Major Tom Lapos and his wife, was a sentimental assignment and perhaps the most delightful years in their Air Force career. He served as Element Leader, Flight Commander, Assistant Operations Officer, Requirements Officer for the Deputy for Navigator Training, Chief of the Course Development Branch, and, finally, Commander of the 3538th Navigator Training Squadron. Also, he completed his academic education through a Masters Degree in Business Administration. He was promoted to Lieutenant Colonel while at Mather.

Next he was off to Lackland AFB, Texas to serve as the Deputy Commander of the newly formed USAF Special Treatment Center (STC), mission: Rehabilitation for Air Force drug abusers. The TDY terminated with a PCS in March 1972. Colonel Lapos remained with the Treatment Center until it was deactivated in May 1974. He was promoted to full Colonel during this assignment.

From July 1974 to July 1975, he was Director of the United States Air Force Social Actions Training School which was under the School of Applied Aerospace Sciences at Lackland AFB. While with the Department of Social Actions Training, Colonel Lapos was responsible for the Air Force's Equal Opportunity and Treatment Training, Drug/Alcohol Rehabilitation Training, and had responsibility to the Defense Race Relations Institute (DRRI) for faculty support during the Air Force Unique Phase of the DRRI.

Looking over his military career, Colonel Lapos provides these insights: "As I look back over my 25 years with the United States Air Force, I state without reservations that I found my career challenging, totally rewarding, and I must say with all candor, that I never had a bad job or a job I didn't like. I have found all of my Commanders to be fair, but I must admit, some were tougher than others. As a young officer I was given every opportunity to excel and I was helped along when I needed it most. Now that the door to Operational Command is open to navigators, I expect that the new generation now being trained will find their careers equally, if not more, exciting than I. Now that I am away from my profession—navigation—I miss the solemn purpose of the briefing room, the excitement of the flight line, the visual sense of accomplishment when a mission is in progress or the debriefing is concluded. The world of the navigator and flight crew member is a world of immediate rewards. You don't need the results of a long range research project to tell you that you have been doing a good job. When you plot a fix, work the tone on a RBS run, or call for the "Green Light" on an air drop, your feedback is instantaneous. You know you've done a good job. When the Form 781 is closed at the end of the sortie, you know what you have accomplished and even on a bad day you are overcome by a sense of pride. You will remark, 'I have had better days than today, but I have sure learned a great deal.' This, to me, is the world of a navigator, exciting, challenging, rewarding, exacting, demanding, and a world of lasting friendships and teamwork—a profession with a purpose."

From The Editor

Editorial

This issue of THE NAVIGATOR maintains the bicentennial theme introduced in our last magazine. Excerpts from "Navigation North of Seventy" should give all of you an inkling of what it was like to be a pioneer in polar aerial navigation. You will see how the men of the 46th Reconnaissance Squadron had to develop new procedures and expand on old methods to navigate throughout the Arctic. "Space Orbital Positioning" proves once again that even the most advanced navigational system should have a backup. Major Garcia discusses the experiment which the astronauts performed on Skylab to position their craft in orbit by using a space sextant. I've tried to print in this issue a sprinkling of topics to please most of our readers. The topics you, our readers, have suggested through the reader survey will be of utmost benefit in our continuing quest to publish a periodical which fits the needs and desires of each of you.

The Summer issue will be my farewell endeavor for THE NAVIGATOR. This Fall I will be attending Air Command and Staff College. Your next editor will be Captain John N. McClain. The position of editor has been one of the most rewarding jobs of my career. I know that I leave the magazine in good hands. Thank you all for supporting THE NAVIGATOR.

How to submit an article to THE NAVIGATOR

Most of the material published in THE NAVIGATOR magazine consists of articles which have been voluntarily contributed by navigators throughout the Air Force. With the new OER system, specific examples must be given on the front of the form to gain the highest scores on appropriate blocks. *Your* article published in THE NAVIGATOR magazine gives *you* a specific to gain an overall higher rating than your contemporaries in this very competitive system. If we do print your article, you will receive, via your commander, a letter of appreciation. Even if your contribution is not printed, we will send you a letter acknowledging your efforts. Do your part toward advancing the profession—as well as your career—make your ideas and experiences available to your fellow navigators by submitting them for publication in THE NAVIGATOR.

SUBJECTS: Any article relating to Air Force navigators and the field of aerial navigation is appropriate. You can see that an almost infinite variety of subjects is available. The choice, of course, will depend upon *your* particular interests. Here are some general areas to consider:

- Informative operational experiences.
- Improvements to existing procedures, techniques, and equipment.
- New or proposed navigational concepts and equipment.

The selection of the subject and writing style are prerogatives of the author. However, articles should neither be reprints of material which has recently been readily accessible to Air Force navigators nor verbatim restatements of AFR, AFM, TO, etc. material. Classified information cannot be used.

REVIEW AND CLEARANCE: An important consideration is that the article be formally cleared for publication. This can best be accomplished through your base information officer. He will insure that your manuscript is properly reviewed and cleared prior to release. SAC personnel should refer to SACR 5-3 for submission procedures. All manuscripts should include a letter indicating security and policy review and clearance for publication in accordance with pertinent AF and command directives.

FORMAT: All appropriate material is solicited. The manner of presentation can be prose, poetry, or cartoon. Writing style may be narrative or technical. Manuscripts should be double spaced and include a suggested title and the author's grade, name, and organizational address. Only one copy is required. Include a short biographical sketch and photograph (Dress Blues) of the author.

SUPPORTIVE MATERIAL: The old saying about a picture being worth 10,000 words still has a lot of teeth in it. Carefully consider whether or not your manuscript would be improved by illustrative material. Diagrams, charts, photographs (preferably glossy black and whites), etc. are often the key to putting an idea across.

Put your improvement, innovation, humorous comment, or interesting experience down on paper and send it along. Our address is:

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The cover of this issue of THE NAVIGATOR depicts the environment in which the men of the 46th Reconnaissance Squadron performed their missions. The feature stories have been extracted from "Navigation North of Seventy." A line navigator wrote this history of the experiences of his squadron as they struggled to develop and then perfect polar navigation procedures.

The Editor

Navigation North of SEVENTY

Editor's Note: The following articles have been extracted from Navigation North of Seventy, authored by First Lieutenant David J. Haney in 1948. Lt Haney compiled his information while a member of the 46th Reconnaissance Squadron in the late '40s. The squadron, flying B-29s, logged over 10,000 hours in two and one-half years over the polar regions. During this time period they tested polar navigational techniques, new equipment, and refined their skills for traversing the Arctic. It was Lt Haney's desire "that polar navigators of the future use this history as an orientation, and a basis from which he can develop his own refinements and techniques without having to experience situations that have already been met." I'm sure all of you will gain a greater appreciation for the sophisticated navigational equipment we all take for granted after reading these historical articles.

Review of Polar Flying

The first attempt to fly over the Polar Sea was made by a Swedish aeronaut named Andree in 1897. Since then, there have been many flights in both lighter-than-air and heavier-than-airplanes over the Arctic Ocean. Admiral Richard E. Byrd made the first flight over the geographic north pole by airplane in 1926. Three days later Amundsen and Flenworth flew over the pole in a lighter-than-air ship, the Norge, from Spitsbergen to Teller, Alaska, this being the first flight across the Polar Sea. Sir Hubert Wilkins and Ben Eielson made the first landings on the polar pack in 1927. About a year later they flew from Point Barrow, Alaska, to Spitsbergen over the magnetic polar area.

Of all the circumpolar governments, Russia was the first to give active support to polar aviation. In June and July 1937 two Russian planes flew from Moscow to the United States pioneering a proposed transpolar airway. In August of the same year a Russian passenger-type plane, commanded by Sigismund Levanevsky, was lost attempting to make the Arctic crossing.

The last radio communication with the plane indicated only that they were going to crash-land. No approximation of their position was given. When they were overdue, three aircraft from Pan-American Airways subsidiary in Alaska took off from Fairbanks to search for the missing plane. These aircraft thoroughly combed the winding river valleys, the tundra country and the Brooks mountain range between Fairbanks and the Arctic Ocean. They flew over 100,000 square miles of Northern Alaska in the hope that Levanevsky had reached Alaska before being forced down.

Sir Hubert Wilkins was in charge of the search for the Russian plane on the American side of the

pole. He flew a total of 44,000 miles in a Consolidated flying boat and a Lockheed Electra, without finding any trace of the missing plane or its crew. Sir Hubert's flights during the late summer and winter proved that Arctic Navigation could be done effectively during at least two seasons of the year.

While the U.S.S.R. was eager to develop its Arctic resources and northern flying techniques with an eye on future transpolar commerce by air, the Canadians have taken little interest in their geographical advantages in regard to polar aviation. It appears the Canadians assumed the Northwest Territories to be a bleak, snow clad country populated by a few Indians, Eskimos and police outposts.

Aviators, however, were quick to see that the climate and topography made surface travel difficult and slow. They realized, too, that to operate aircraft successfully would require special techniques. Bush pilots perfected their own techniques for arctic operations and were soon flying at a profit in the subarctic regions.

Since the airplane first penetrated to Fort Simpson in 1921, it has steadily stimulated the development of the Arctic. In 1922 Sherman Fairchild started the first air transport company to carry passengers and freight in Canada and subarctic regions. The Canadian Air Force made some important survey flights in the Western Arctic in 1927. Colonel Lindbergh's flight from Washington to Tokyo in 1931 for Pan American took him by Churchill, Baker Lake, Aklavik and Point Barrow. In 1933 Colonel Lindbergh made other exploratory flights for Pan American over Labrador, Greenland, Baffin Island and Iceland.

By the end of World War II, airplanes were operating regularly from Point Barrow to the United States. Navigational aids were installed and emergency strips constructed to allow safe and frequent service to many otherwise isolated districts. Although many advances have been made in commercial aviation throughout the subarctic, it was not until after V-J Day that the Air Forces began investigating the possibilities of polar operations.

The flights made by Byrd, Ellsworth and Sir Hubert Wilkins provided about all the information available on actual polar flights. These flights proved that aerial navigation was not an insuperable problem without the benefit of navigational aids. Yet to really make progress in polar navigation, there was a need for regular flights over the polar area. The 46th Reconnaissance Squadron, under command of Major Maynard E. White, was sent to Alaska in the summer of 1946 to begin a program of extensive polar exploration. Polar "Know how" did not exist, within any one group, when the Squadron was alerted for their project. Articles, Pamphlets or other material on the north had not been catalogued or a library kept; therefore it was difficult for navigators to familiarize themselves adequately for their mission.

The navigators, when informed that their missions were to be over the polar ice cap, began a widespread search for information on polar navigation. The complete lack of this material made them realize that this mission was not going to be routine. The material available dealt for the most part with subarctic operations and theories as to the best polar procedures. So many theories, and each different, about the most practical methods tended to frighten rather than enlighten them.

It was known to crewmen that considerable time had been given to the study of air navigation methods for polar regions. However, none of this information seemed to be available in June of 1946. Harold Gatty had been commissioned by the Navy Department in 1944 to make a study of navigation knowledge at that time. His report was completed early in 1945 and was given limited distribution but was not available to the 46th Squadron.

The navigators did have the opportunity of talking with the members of the B-29 Detachment at Edmonton, Alberta, Canada. It was through them, and only them, that they received any practical and usable information. With this limited background the Squadron started its polar operations.

Grid navigation is a comparatively new concept of the navigational problem near the poles. The first known written paper on the subject was by Admiral L. Tonta in 1929. In this paper Admiral Tonta gives his ideas of Grid variation and convergence. Unless an earlier source is found, this paper may be considered as the first introduction of the Grid System.

Wing Commander K.C. Maclure, in 1941, wrote the results of his developments of a Grid System, especially for use with the astro compass, and employed this system in the 1945 flights of the "Aries".

The reason that the first description of such a system came so long after the first flight is, more than likely, because there was no earlier requirement for it. The early flights were all for the purpose of reaching the pole—not getting

back. There was no convergence of meridians, the magnetic polar area was not close to the flight lines, and simple astro compasses, such as the Bumstead in which a clock mechanism compensated for the changing L.H.A. of the Sun due to the earth's rotation, sufficed for steering.

It appears that the Navy was the first to experiment with Grid navigation in synthetic trainers in the United States. These experiments were carried out at the Naval Air Station, Quonset Point, Rhode Island, as a result of conflicting grid orientations that had been advanced by various individuals. The Navy had been considering computing and developing high latitude tables for quite sometime. At the insistence of Lt Commanders D.D. Miller, E.E. Packard, Commanders C.H. Hutchings and W.J. Catlett, the Hydrographic office started computing the Air Navigation Star Tables. At approximately the same time, Sergeant Goettz and Lt Hoy of the Air Force were preparing polar navigation tables at Wright Field, Ohio. The Goettz tables and the Navigation Star tables were completed about the same time. These tables agreed on grid orientations, however, they differed from the grid orientation recommended by Gatty.

As a result of the conflicting views as to the best grid orientation, the Navy initiated the experiments to test all three. Dr. Samuel Herrick had recommended that grid north be from the pole along the Greenwich meridian toward England. Goettz had the formula in his tables for an orientation along the 180th meridian toward the Pacific Ocean, Gatty advanced the theory that the 90 East or West meridians would be more practical. After about 400 hours of synthetic flying in the Link Celestial Trainer between latitudes 83 and 87 north, testing each of the orientations, it was agreed by the navigators that grid north oriented parallel to the 180th meridian would be most practical.

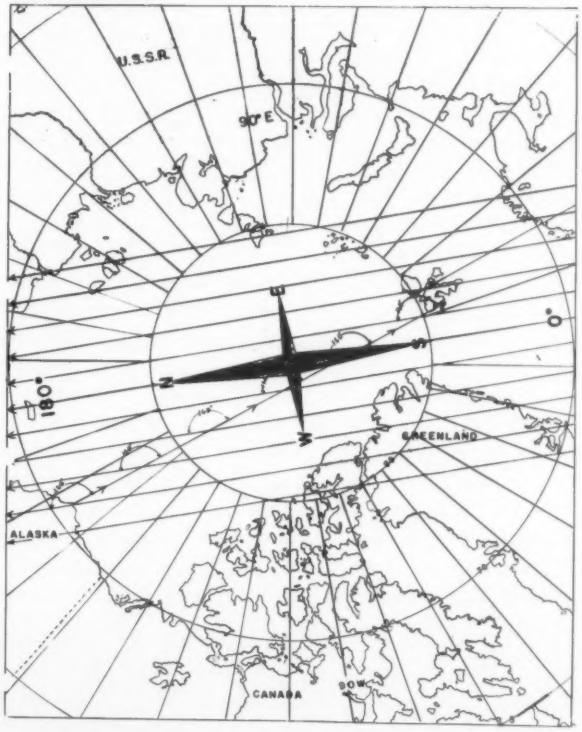
In January of 1946 Commander Catlett was directed to deactivate his project at Quonset Point. He managed to keep it going long enough to test Volume 9 of H.O. 214 tables and give two teams of B-29 navigator's a course in polar navigation. They were to join the Musk-Calf operation at Edmonton, Alberta, Canada. They later passed on the information they had gained at Quonset Point, with their actual experience, though limited at the time to the navigators of the 46th Squadron. The navigators of the 46th will always be grateful to Lt William E. Gray and his colleagues for their help in the Spring of 1946.

Difference Between Polar And Low Latitude Navigation

Before planes were able to fly safely and regularly over the polar area, many problems had to be solved and definite steps taken to overcome unexpected or unknown problems that may occur in flight. It was known to navigators that the only method of fixing position would be by celestial methods, due to inaccurate and inadequate charts, extensive ocean areas, and no navigational aids (i.e. radio, Loran or D.F. facilities). Other aids to navigation that were not available in polar regions are such man-made pilotage points as cities, dams, railroads, etc. Knowing this, navigators made plans accordingly by brushing up their techniques in dead reckoning and celestial.

Most navigators in the Air Force have found themselves many times to be without the above listed navigational aids due to a number of reasons during the war. The two things that caused them to lose sleep was losing the long practiced methods of course measurement and steering. All our lives we compared geographical points in relation to north. We have always known that the sun rises in the east and sets in the west. In the polar areas this is not true. At the pole there is only one direction, that being south. The sun either doesn't rise at all or appears to spiral upward in the spring, then downward in

Polar Stereographic Projection with Grid Lines oriented to the 180th Meridian.

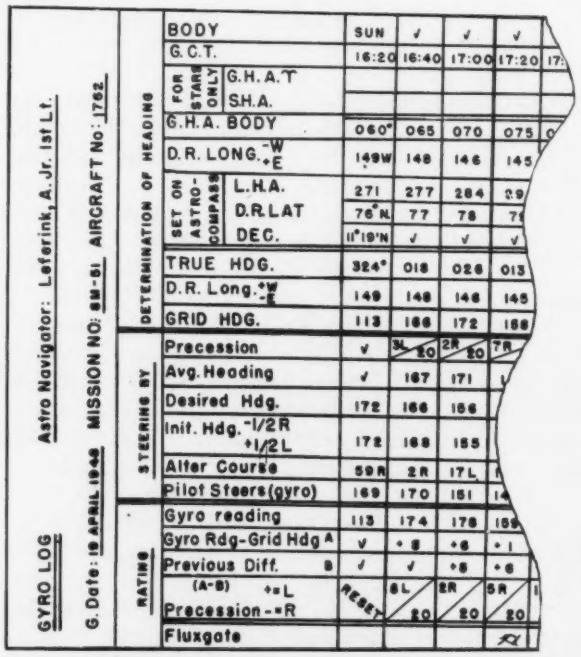


the fall until it disappears for six months. Even at as low a latitude as Fairbanks the old rule, rise east, set west is not true. In mid-winter the sun rises slightly southeast and sets southwest. In the summer it rises just east of north and sets just west of north.

To further the early Air Force polar navigators' worries, authorities could not agree on a grid orientation most suitable for practical use. This grid orientation is the method of measuring direction to get a constant value for desired course. If true direction were attempted, it is apparent that an aircraft approaching the pole on a true heading of north will immediately, upon reaching the pole, have a true heading of south. Not only that but any other heading he may try to take would be south. Crossing the geographic pole is not the only time direction definition would be difficult if true north were used as reference. If the course of an aircraft were to pass near the pole, but not directly over it, the true heading might be northeast at the beginning of the flight, changing to east at the point nearest the pole, and then southeast when withdrawing from the pole. To overcome this nuisance of converging meridians, the Grid System was adopted.

As mentioned earlier, various individuals had made recommendations as to their theory on the most practical grid orientation. Following the recommendation of Commander Catlett, the navigators of the B-29 detachment at Edmonton adopted the 180th meridian for heading reference. This system was passed on to the navigators of the 46th Reconnaissance Squadron a few months later. The way this system works is quite simple. An observer standing at the north pole facing down the 180th meridian with his back to the 0 degree meridian toward England would be facing north according to grid reference. As he faced the 180th meridian and the Pacific Ocean, his east would be the 90th east meridian, or Russia. England would be grid south and Canada grid west. Thus, by placing lines parallel to the 180th meridian, separated enough to allow convenient course measurement, his reference system would be set up. Any courses measured with reference to these lines would give a constant value for direction.

When the grid is superimposed on the polar stereographic chart and the heading measured in a clockwise direction from grid north, the problem of steering must be overcome. Grid headings usually are radically different from true headings. Obviously the magnetic compass cannot be utilized in the conventional manner because the



GYRO LOG — Astro Navigator: Leferink, A. Jr. 1st Lt. — G. Date: 19 APRIL 1948 — MISSION NO: 88-81 — AIRCRAFT No: 1762

DETERMINATION OF HEADING	BODY	SUN	✓	✓	✓	
	G.C.T.	16:20	16:40	17:00	17:20	17:
	FOR STARS ONLY: G.H.A.T					
	FOR STARS ONLY: SH.A.					
	G.H.A. BODY	060°	065	070	075	0
	D.R. LONG. -W +E	149W	148	146	145	
	SET ON ASTRO-COMPASS: L.H.A.	271	277	284	29	
	SET ON ASTRO-COMPASS: D.R.LAT	76°N.	77	78	7	
	SET ON ASTRO-COMPASS: DEC.	11°19'N	✓	✓	✓	
	TRUE HDG.	324°	018	026	013	
	D.R. Long. -W +E	149	148	146	145	
	GRID HDG.	113	166	172	158	
STEERING BY	Precession	✓	3L / 20	2R / 20	7R	
	Avg. Heading	✓	167	171		
	Desired Hdg.	172	166	166		
	Init. Hdg. -1/2R +1/2L	172	168	155		
	Alter Course	59R	2R	17L		
	Pilot Steers (gyro)	169	170	151	14	
RATING	Gyro reading	113	174	178	158	
	Gyro Rdg-Grid Hdg A	✓	+8	+6	+1	
	Previous Diff. B	✓	✓	+8	+6	
	(A-B) +=L Precession -=R	RESET	8L / 20	2R / 20	5R / 20	
	Fluxgate				✓	

Gyro Log used by the 46th.

lines of equal magnetic variation are oriented for use with true direction. The only time grid heading and true heading are the same is when an aircraft is flying north or south along the Greenwich meridian. If flying north the true and grid heading are both north. However, as soon as the pole is passed the true heading changes immediately to south, but the grid heading remains north.

The instrument presently used for steering is the directional gyro. The directional gyro, unlike the magnetic compass, has no direction seeking ability and must be set to the grid heading. If the directional gyro has no precession, it will give a constant reading over a great circle course, which approximates a straight line on a polar stereographic projection. Since directional gyros do not have a direction seeking ability and will precess, it is not as satisfactory for steering in polar regions as the magnetic compass is for lower latitudes. As a result of precession, it is necessary for the gyro to be checked frequently and reset as the error accumulates.

The only available means of checking the gyro is to use the astro-compass. Constant use of the astro-compass requires the aircraft to fly on top of weather in order to obtain regularly timed shots on the sun or stars. Readings taken at intervals of approximately twenty minutes provide a means of determining precession and applying it with reasonable reliability if an overcast should prevent further observation.

From the first flight, the navigators were faced with many new and unexpected problems. These difficulties had to be ironed out by the navigators themselves as there was no other source of information to help them. By the time analysts had studied the problems and given advice, much time had passed and many flights had been flown. For immediate answers to their problems it was up to the individual concerned to work it out for himself. Most of these difficulties came during flight where it was necessary for the crewman to solve his problem on the spot or look for alternate methods.

On one of the early flights the navigators were having trouble plotting a fix using the pole as the assumed position, this being the first time they had been near enough to the pole to use this solution. After considerable time was consumed and with results they were not sure of, the navigators decided to solve the sights by H.O. 214 tables for confirmation. This took more time than expected and when the celestial navigator took his next observation he found that the gyro had precessed considerably more than it had previously for the same length of time. He took another series of sights with his sextant and the resulting fix indicated that a violent wind shift had occurred while they were working with the new solution. As a result of this jump in precession and wind shift, the aircraft had drifted about fifty miles off course.

It was probably as a result of this drifting off course that prompted an observer from the War Department on board to write the following in his report:

"It is apparent that the navigational instruments and techniques have been improvised from low latitude requirements and are definitely deficient. Celestial navigation has improved during the war and had it not been for the self assurance and quality of the celestial navigation the flight over the pole might have ended disastrously due to the failure in efficiency of other standard instruments, particularly the compasses. This situation is so serious that it shows that present navigational instruments for high latitude have retrograded from those known and proven 20 years ago. When Admiral Byrd flew over the north and south poles for the first time, he used a Bumstead sun compass and was able to ride a meridian directly to the pole and return. He required his sextant only for determination of latitude and to prove that he had reached the pole itself. On the flight in which I was an observer over the North Pole, an attempt was made to ride the 150th meridian by using the fluxgate compass and two systems of gyro compasses with the result that seldom if ever was the plane on the meridian".

Making some allowance for the navigators' limited experience at the time of the flight, other factors probably unknown to the War Department observer at the time of his report should be considered. It doesn't appear likely that high latitude navigational instruments have retrograded in the last 20 years, though it is true that advances of some are limited.

The Sun Compass used by Admiral Byrd consists of a civil time clock with a twenty-four hour dial. The hour hand is replaced by a diametrical bar carrying a pin and a translucent screen at opposite ends. The pin and screen are set parallel to the earth's axis by tilting and clamping the clock, which is mounted on horizontal trunnions. The brackets carrying the trunnions are mounted on a horizontal azimuth dial that may be set to the course desired. In operation the pin and screen are set to local apparent time, the latitude is set to the latitude, and the azimuth set to the required true course. The airplane is then steered so that the shadow of the pin falls on the center of the screen. Since local apparent time changes with longitude, the clock requires frequent resetting unless the airplane flies generally on north or south courses.

The Mark II Astro-compass used by Air Force navigators today is essentially the same as the Sun Compass but it is more modern and practical. It consists of a mount, from which the compass is separable, two leveling screws, a horizontal index, azimuth circle, drum stator, hour circles, declination scale bracket and sighting device. In operation the astro-compass requires, instead of apparent time, the local hour angle of the sun, the declination and latitude. With these data set in the astro-compass, rotate the azimuth circle to the horizontal index arrow and steer the aircraft until the shadow lines up on the sighting device. The two instruments will give the same results if employed in this manner.

Admiral Byrd states in his book, "Skyward", the flight was made during the polar day with clear skies above and below his plane. He says that he kept one eye in the drift indicator almost constantly when not checking heading with the

Sir Hubert Wilkins and Staff Officers of the 46th Recon. Sq.

sun compass. As a result his dead reckoning was very accurate, requiring celestial sights only to confirm dead reckoning positions and the pole itself. The celestial sights made on the trip north indicated he was on course, rather than his latitude.

The flight which the War Department observer's report covered was made on 16 October 1946. The navigators employed the grid system from Point Barrow to the pole and return to Point Barrow. The fluxgate was used only when over the mainland of Alaska. Part of the flight was made in the polar twilight when neither the sun or stars were visible for observation. The aircraft was equipped with the gyro stabilized B-3 driftmeter, which was of no use when the weather was undercast or in darkness. The navigators were dependent on radar and their celestial positions for drift determination. At the time of this flight radar observers were also of limited experience, although their information was found to be quite reliable. Radar is not able to determine a wind shift as quickly as constant visual observation because it is necessary to locate a suitable target and follow it for several minutes.

Because of lack of experience of the navigators and radar observers in polar flying at the time of this flight, the season and weather conditions encountered, it seems unlikely that navigational methods have retrograded; more likely the new techniques had not been perfected at that time.

It is apparent that early thinking in terms of polar navigation has been cluttered with worries about the magnetic compass. Definite strides forward were made when this thinking was abandoned and new methods tried. This is borne out by the early flights by Wilkins. Even though his success strengthened the hope that the magnetic compass could be improved enough to become the primary steering instrument for polar flights, it stresses the need still further for better methods. Mr. Gatty says in his report to the Navy of the Wilkins flight:

> *"On Wilkins' flight from Point Barrow, Alaska to Spitsbergen in April 1928, this was without doubt the most difficult flight navigationally ever flown up to that time. The flight passed through 171 degrees of longitude and 315 degrees of compass variation. He broke the flight down in legs of 100 miles, changing course every hour. Track was carefully worked out; the corrections required for changes in variation and frequent changes of longitude were applied before taking off from Point Barrow. The dead reckoning course when worked out was checked by only eight sets of altitude observations on the sun. It is to be remembered that this flight crossed the belt of low horizontal intensity which extends across the Arctic Ocean. It would be difficult to design a course which presents more navigational complications - yet even here the principal dependence was placed upon the magnetic compass. No routes now being flown present such complicated problems in navigation".*

There is little doubt that if an attempt should be made to fly regularly over this route with the methods used by Sir Hubert, polar navigation would never be very practical for Air Force or Commercial operation. This flight was indeed a magnificent job of navigation for the period in which it took place and the aircraft of that time. By contrast, the Air Force today is sending planes almost daily over the same areas covered by Wilkins and Eielson. Instead of magnetic compasses, gyros are steering the aircraft along a Great Circle course with a minimum amount of difficulty.

It is time to realize the fact that grid reference for course measurement and gyros or some other non-direction seeking instrument for steering are here to stay awhile. No matter how many aids to navigation may be installed over the polar area, a constant value for course measurement and an instrument free from influence of the earth's magnetic field will for a long time be preferred by navigators. Not that the magnetic compass is useless; rather it is impractical for use when simpler, more efficient methods are available.

SEXTANT

and SPACE NAVIGATION

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From the Ark to Skylab, man has used the heavens as an aid to navigation. First, the heavens were used to determine direction via the Pole star. Secondly, as mathematics and optical instruments (sextants) were developed, the heavens were used to calculate lines of position (LOPs) and/or definite fix positions. To calculate accurate direction (heading), an LOP, or fix position, the angular relationship between the observer's horizon and the celestial body in question must be determined using suitable optics, e.g. a sextant. The sextant allows direct measurement of star to horizon angles using actual sea or land horizons (marine sextant), or an artificial (bubble) horizon (modern aircraft sextant). These variations of sextants produce reliable and reasonably accurate results for the earthbound or airborne navigator.

As man ventures into space, navigation is accomplished via sophisticated automatic avionics. But man must develop the ability to work in space, make judgments, repair equipment, and perhaps most importantly, act as a backup system if primary avionics fail. As a result of a 1973 experiment onboard Skylab, the sextant, one of the most basic of instruments, has found a niche in the manned space program as a manual aid to navigation.

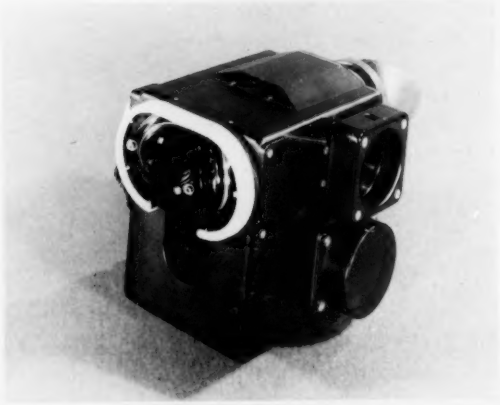
Space navigation is defined as the determination of six independent orbital parameters which specify uniquely the size, shape, and inertial orientation of the orbit in space. These orbital parameters may be in the form of position (x,y,z components) and velocity (x,y,z components) which can be used to accomplish a safe re-entry if loss of communication is experienced or if the primary onboard avionics fail.

THE T-002 EXPERIMENT

The 1973 Skylab T-002 experiment was a joint USAF/NASA project designed to investigate man's ability to make accurate navigational measurements during long-term space flight and to investigate the feasibility of employing a manual navigation system as a backup to primary system avionics. The NASA objective was concerned with the astronauts' ability to perform angular measurements (known star-to-moon, known star-to-known star, known star-to-earth horizon) under the conditions of long term weightlessness. These angular measurements are typical of those used by NASA for midcourse trajectory corrections. The Air Force was interested in performing an operational check of a manual space navigation system developed in the late sixties which involved the use of a handheld space sextant, a handheld space stadimeter, and a manual orbit computation scheme.

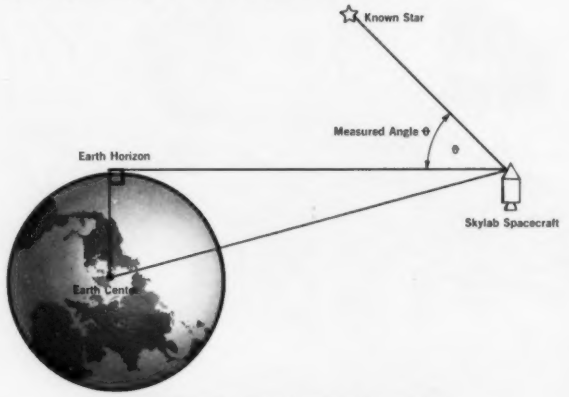
The AMES Research Center conducted the NASA portion. A separate T-002 report, which will not be discussed in this article, was produced by Mr. Robert Randle, the NASA Principal Investigator. The Air Force portion was initiated by the Aviation-Science Division (formerly the Navigation Division), United States Air Force Academy, under the sponsorship of the Space and Missile Systems Organization (SAMSO), Air Force Systems Command. The first Air Force Co-Principal

Investigator was Lt Col Stanley W. Powers, formerly of the Aviation-Science Division. Lt Col Powers reported on the preliminary Skylab results (Skylab II data only). Major Richard C. Walsh, the second Co-Principal Investigator, and Captain Jackson R. Ferguson, both of the Department of Astronautics and Computer Science, United States Air Force Academy, completed the T-002 project and wrote a final report which combined the data collected on Skylab II and Skylab III. The final report also included a new approach to processing manual navigation data.

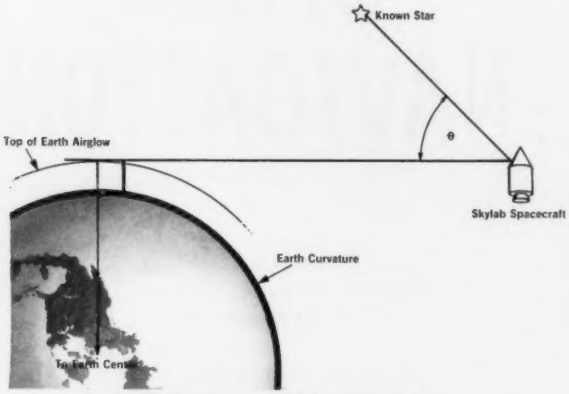


Handheld Space Sextant.
Figure 1

Handheld Space Sextant. The sextant was developed for NASA by Kollsman (Figure 1). The sextant incorporates two lines of sight (two separate telescopes sharing a common eyepiece). Through a series of optics and controls, the image from each line of sight is erect and when superimposed on the focal plane establishes the angular separation between a known star and the earth's horizon (Figure 2 and 3). Known star-horizon angles combined with accurate GMT were used to compute the six orbital parameters. The space sextant's limited (7°) field of view and 8-power magnification resulted in initial star identification/acquisition and horizon definition problems. The star identification/acquisition problem was overcome with practice. The horizon definition was overcome by sighting to the top of the earth's airglow which was usually distinct and observable. Each sextant derived angular relationship was compared to a computed star-earth angle. The computed angle was derived from known spacecraft coordinates, star position, times, and assumed earth radii. Mean height and standard deviation (variability) of the sighted earth horizon and precision of the measurements were calculated. Analysis of the Skylab data confirmed that the top of the earth's airglow sighting provided the most reliable mean and standard deviation measurements. The sextant data proved to be twice as precise as stadimeter height measurements. Sextant data was acquired by Major Lousma on Skylab II.



Handheld Space Sextant Geometry
Figure 2

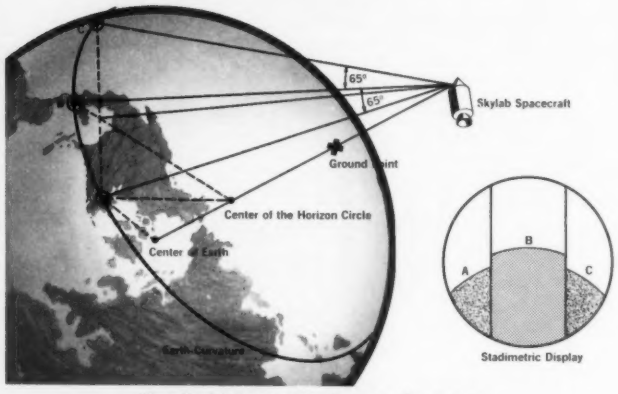


Actual Space Sextant Geometry
Figure 3

Handheld Space Stadimeter. The stadimeter was developed by Kollsman for the Air Force (Figure 4). This was used solely on Skylab III and combined with sextant sightings on Skylab II. The stadimeter optics incorporate three separate telescopes which share a common eyepiece. Two lines of sight (65° apart) are combined with a center line of sight which is capable of scanning along a perpendicular bisector of the plane of the two fixed fields. The angular readout is the separation between the chord of the center arc and the line connecting the centers of the outer segments (Figure 5). This angular readout is directly related to the altitude (range) of the spacecraft above the curved horizon. A computer programmed with stadimeter equations

produced the measured spacecraft altitude (range). The spacecraft altitude data was compared to a NASA ephemeris, and a mean and standard deviation was derived for each sighting. Preliminary and final results revealed an inadequacy in the stadimeter determined altitude (range). The inadequate results were related to the variable day-earth horizon characteristics which created difficulty in aligning the optically dispersed (65^0) segments of the earth's horizon. Stadimeter data was acquired by Major Lousma on Skylab II. Lt Col Pogue acquired all of the stadimeter data on Skylab III.

Handheld Space Stadimeter.
Figure 4



Handheld Space Stadimeter Geometry
Figure 5

Major Walsh and Captain Fergusons' research integrated all of the data from the Skylab II and Skylab III sightings. They re-analyzed the data with a new NASA precision ephemeris and developed a new effective, data processing scheme (the scheme developed in the late sixties was found to be inadequate due to the nature of the sextant/stadimeter data, which was not as precise as first assumed due to the variable, indistinct horizon reference). The data processing scheme developed employs a least-squares differential correction (LSDC) process which statistically averages out random measurement errors and solves for the uncertain horizon height. The LSDC technique does not require altitude data and thus the stadimeter may be removed from the manual navigation system. Major Walsh and Captain Ferguson also recommended that a mini-computer and a new handheld space sextant be combined into a self-powered manual navigation system. The combination of a mini-computer and sextant could automatically process acquired data while in space. Total weight of this system could be less than five pounds.

CONCLUSION

A manual navigation system employing a space sextant is a viable backup system providing autonomy and reliability in a space environment. The manual system can perform independently when major subsystem failures occur or during communication loss, all at a fraction of the cost of ground tracking support.

Major Freddie Garcia, Jr., is a 1965 graduate of the U. of S. Florida. His first assignment was as a Deputy Missile Crew Commander at Ellsworth AFB, South Dakota. He graduated from UNT in 1968. His first flying assignment was to SEA in EC-47s. From SEA he went to MAC and then on to an exchange tour to the RAF College of Air Warfare as a student in the No. 4 Aerosystems Course. He is presently the course director for the Advanced Systems and Concepts Course.

Major Richard C. Walsh is a 1964 graduate of the USAF Academy. His first assignment was as Executive Officer of the 3525th OMS, Williams AFB, Arizona. He gained an M.S. in Engineering through AFIT in 1969. His next assignment was as a Satellite Test Planning Officer at the test center at Sunnyvale, California. Major Walsh is currently an Assistant Professor of Astronautics in the Department of Astronautics and Computer Science.

Airpath Turn

Lt Col Andrew LABOSKY, Jr.
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Editor's Note: This is a review of a basic drafting technique as it applies to high speed (Jet) navigation. Unlike slow speed navigation (Prop) which allowed us to depict "square" turns, high speed navigation requires us to allow for the turn radius. The description of the airpath turn allows the navigator to accurately determine a position after a turn, regardless of the bank angle, speed, time in turn or number of degrees turned. The method shown in this article allows the navigator to select the degree of bank angle necessary to place the aircraft on a desired track. Also, the technique can be utilized to maintain orbits, or as an aid to mission planning.

With the advent of jet aircraft, navigators were confronted with an additional navigational DR problem associated with high speed DR techniques. This problem concerns the large radius of turn and the speed of the aircraft as depicted on the navigator's map. To account for this airpath while in a turn, airplot techniques were used. This technique was nothing more than the classic wind triangle curved to fit the conditions. The amount of curve depended upon the true air speed and bank angle. As time went on these basic procedures tended to be overlooked.

The Airpath Turn/Drafting procedure, has been adopted for use by SAC's 4017th Combat Crew Training Squadron and the Instructional Systems Development section of the 93d Bomb Wing, Castle AFB, California. This procedure is now taught as the primary method of executing a DR turn. The airpath turn technique has been adopted because:

1. It is easily drawn using a template.
2. It can be plotted before turns.
3. It can be used through all degrees of turn.
4. It is accurate for all airspeeds.
5. It is accurate for all bank angles.
6. It is easy to understand.
7. It is accurate.

The procedure is used for mission planning, inflight DR and airplot, at any airspeed, bank angle, altitude, or degree of turn. In order to accurately and graphically depict the air mass path of an aircraft during a turn, it is necessary to determine the radius or diameter of the turn. This diameter, in miles, is compared to the map mileage scale to be used and the size of the hole in the draftsman's template. This diameter or radius is obtained by entering the bank angle/diameter graph (Figure 1) with the true air speed and bank

AIRPATH TURN DIAMETER CHART

DIAMETERS, BANK ANGLE & TAS

TAS	30	25	20	15	10
300	4.3	5.3	6.8	9.3	14.1
310	4.7	5.8	7.5	10.2	15.5
320	5.2	6.4	8.1	11.1	16.9
330	5.6	6.9	8.8	12.1	18.3
340	6.0	7.4	9.5	13.0	19.7
350	6.5	7.9	10.1	13.9	21.1
360	6.9	8.5	10.8	14.8	22.5
370	7.3	9.0	11.5	15.7	23.9
380	7.8	9.5	12.2	16.6	25.3
390	8.2	10.0	12.8	17.5	26.7
400	8.6	10.6	13.5	18.5	28.0
410	9.1	11.1	14.2	19.4	29.5
420	9.5	11.7	14.8	20.3	30.8
430	9.9	12.2	15.5	21.2	32.2
440	10.4	12.7	16.2	22.1	33.6
450	10.8	13.3	16,8	23.1	35.1
460	11.3	13.8	17.5	23.9	36.4
470	11.7	14.3	18.2	24.9	37.8
480	12.1	14.8	18.9	25.8	39.2
490	12.6	15.4	19.5	26.7	40.6
500	13.0	15.9	20.2	27.6	42.0

NOTE: DIAMETERS ARE AIRPATH DIAMETERS AND DERIVE AIRPOSITIONS

Figure 1

angle to be made. It is assumed that the pilot will provide the requested bank angle, airspeed, heading and altitude.

During mission planning, this is essentially airplot with no wind effect. Inflight, however, it is also airplot, but with wind vectors for wind effect applied.

BASIC STEPS

1. Determine that a turn is needed and to be drawn on the chart.
2. Determine true airspeed to be used.
3. Determine bank angle to be used.
4. Determine roll out heading (inflight).
5. Determine roll out track (mission planning).
6. Enter chart with TAS and bank angle.
7. Extract diameter in nautical miles.
8. Select proper size hole in the template.
9. Place proper template hole tangent to the inbound heading or track and draw the circumference to the approximate rollout.
10. Construct a rollout heading or track line tangent to the circumference.
11. Complete air distance for the selected amount of time.
12. Plot the air distance. (This is the resultant airplot position.)
13. Apply the wind vector for the same amount of time. (This is the DR position.)
14. Any amount of time can be used, i.e. rollout time or time to next position.

LOG PROCEDURES

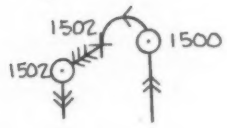
1. See log sample (SAC procedures).
2. Enter the time, air position symbol+, and

SAMPLE LOG & CHART PROCEDURES FOR AIRPATH TURN

START TURN D.R. TO ROLLOUT D.R.

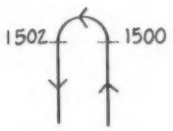
TIME	FIX SYM.	PRESENT POSITION	T.C. OR G.C.	WIND	DC	T.H. OR G.H.	VAR OR ½ PREC.	M.H. OR AGH	TAS	AIR DIST.	DIST. / TIME
1500	⊙										
1500	A/H										
1502	+ ⊙			045 / 80					440	14	02

CHART PROCEDURES



START TURN AIRPLOT TO ROLLOUT AIRPLOT

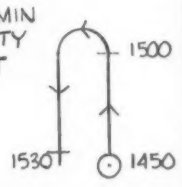
1500	+										
1500	A/H										
1502	+			360 / 000					440	14	02



START TURN AIRPLOT TO DOWN TRACK AIRPLOT

1500	+										
1500	A/H										
1530	+			360 / 000		180			440	220	30

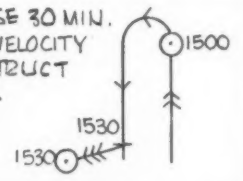
NOTE: USE 40 MIN OF WIND VELOCITY TO CONSTRUCT 1530 D.R.



START TURN D.R. TO DOWN TRACK D.R.

1500	⊙										
1500	A/H										
1530	+ ⊙			045 / 80		180			440	220	30

NOTE: USE 30 MIN. OF WIND VELOCITY TO CONSTRUCT 1530 D.R.



DR symbol ⊖ in appropriate blocks. Next, place the wind used for the vector, constant turn symbol or heading in degrees after rollout, TAS, air distance, and total time.

The wind information should be entered on the log in order to plot it on the chart. This is required on navigation legs that require airplot to be used. On other legs, such as those that allow doppler to be used, the wind used should also be annotated on the log. The inbound and outbound average doppler wind to the turning point may not be the same as the wind encountered locally at the turning point. It may be a good procedure where the inbound leg is long, to enter in the log, an instrument reading just before the turn, in order to further justify the wind used. When changing altitudes in the turn, it may be also advantageous to average the wind noted before the turn, with the wind noted at rollout, due to wind shear.

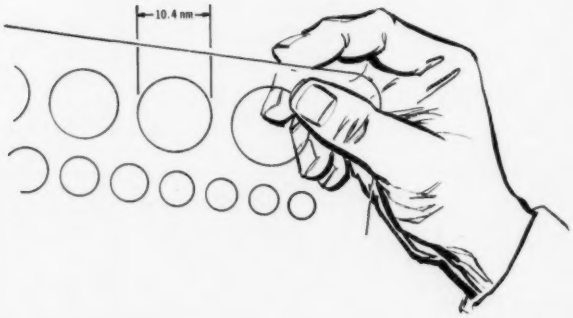
TEMPLATE USAGE

For selecting the proper hole, lay the template on the nautical mile TIC marks on the map to be used. Allow for the size of the pencil or ball point pen and for interpolation. The air distance is measured by walking the dividers around the circumference of the turn, in some value easy to use such as 5 n m increments. A parallel line or tangency TIC mark on the template should be utilized for proper draftsmanship.

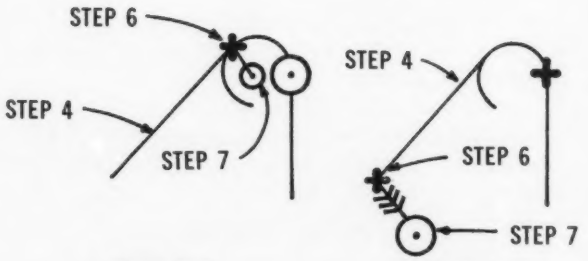
Now that we've seen the basic steps let's walk through a sample problem.

1. Determine diameter of turn in n m s by entering chart with TAS and bank angle. Example: 440 TAS and 30° Bank Angle = 10.4 n m.

2. Select proper template hole size that corresponds to the diameter of the turn.



3. Place template tangent to DR (Example 1, Inbound TC) or Airplot (Example 2, Inbound TH) and construct turn Airpath from start turn position.



Example 1 Example 2

4. Construct TH line tangent to circumference. See example.

5. Derive nautical air miles (NAM) from start turn position to desired position after turn.
440X2:00 = 15 NAM (Example 1)
440X30:00 = 22 NAM (Example 2)

6. Arc off NAM around the airpath turn to establish the airplot position. See example.

7. Construct a DR position from after turn airplot position. Be careful to use proper time to derive correct wind effect.

ALTERNATE CHOICES

1. The "PI" method: The total distance traveled in a 360 degree turn (time versus TAS), (circumference), divided by 3.14.

2. Turn diameter extract from AFM 51-37.

3. Radius at low altitude chart.

4. Air refueling rendezvous turn range offset chart using zero drift. (The offset is diameter.)

Note: Each of these alternate methods have inaccuracies because of the basis of chart construction, unusable situations, and the use of rate of turn per second, which will vary bank angle.

I think once you have tried the Airpath Turn you will find it a very simple and accurate technique. If you want additional background information concerning this method, refer to SACP 55-10.

Lt Col Andrew Labosky, Jr., is an academic instructor at the Strategic Air Command's KC-135 CCTS. He entered the Air Force in 1958 through the Aviation Cadet Program. During his career, he has flown in both the B-47 and KC-135 aircraft, accumulating over 5,000 flying hours. Lt Col Labosky was the navigator on the KC-135 crew that won the Saunders Trophy for the 11th ARS during the 1970 SAC Bombing/Navigation Competition.

Computer Case

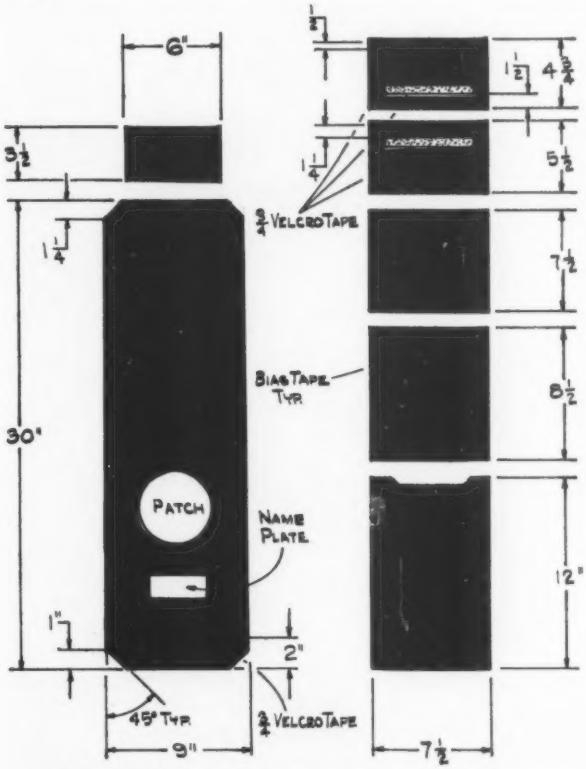
Major William E. BLUE
305 BMW
Grissom AFB IN

Editor's Note:
I'm sure many of you have had occasion to fumble through your nav bag looking for that elusive pair of dividers, a pencil, or a plotter. How about at rotation when your computer slides off of the desk? This computer case could be just what you need, an easy to get at container for all of these items.

Has your old computer case worn out? This case may be what you are looking for. The case will store your computer, plotter, dividers, watches, templates, and pencils. Your biggest cost will be the ½ yard of naugahyde upholstery material. I made the case pictured for about $4.00. Most of the sewing can be done on a home machine. The heavy sewing, where three or more pieces are sewn together, should not be attempted at home. Your local parachute shop or a shoe repair shop can do the final sewing.

You will need the following materials:
½ yard of 42 inch wide naughahyde material. 1 package of double fold bias tape. 12 inches of ¾ inch wide velcro tape.

1. Draw the pattern on the wrong side of the material with chalk.
2. Number each piece of the material.
3. Cut out the pieces.
4. Sew the seam binding tape to the top of pieces #1,2,3,4 and #5.
5. Sew seam binding tape inside of square of the name plate #7.
6. Sew seam binding tape on one end of the name plate #7.
7. Sew pieces #7 on to the right side of piece #6. Sew 3½ inches from the bottom of #6 and 1 ½ inches from each side.
8. Sew your squadron patch on the front if desired.
9. Sew 6 inch strip of Velcro tape on to #6 wrong side of material 2 inches from each side.
10. Sew the other piece of the 6 incn strip of Velcro tape onto #1 right side of the material 1½ inches from the bottom and ¾ inches from each side.
11. Sew 5 inch strip of Velcro tape on #1 wrong side of material ½ inch from each side.
12. Sew the other piece of the 5 inch strip of Velcro tape on to #2 right side of material.
13. Sew piece #3 to piece #4 using seam tape and sew to divide the middle.
14. Glue edges together with contact cement that are to be sewn at the parachute shop or a shoe repair.



Major William E. Blue is a 1961 graduate of Aviation Cadets, Harlingen AFB, Texas. His first operational assignment was in KC-135s to Loring AFB, Maine. He was an instructor in the aircraft until 1972 when he was assigned to C-130s in the 21st TAS, CCK Air Base, Taiwan. In July of 1973 Major Blue returned to KC-135s at Grand Forks AFB, North Dakota. Major Blue is presently in DOTN at Grissom AFB, Indiana.

AIR SUPERIORITY GIB

Captain Roger E. ROSENBERG
MPC/Navigator Career Management
Randolph AFB TX

Having sought an F-4 assignment for several years, I had done a lot of reading about and talking with F-4 GIBs and felt I had a pretty good handle on what this job was all about. Of course there was radar low altitude navigation and radar weapon delivery. As an ex-B-52 nav, I could handle that. There were all sorts of things to do on the gunnery range; call off altitudes in the chute, catch dive angle and airspeed at release, visually score the bomb, and keep the other aircraft in sight. Air-to-air—that's really the pilot's world, isn't it? Maybe a little radar intercept work against a high flying bomber, but generally it was probably "grab the canopy rails and hang on."

Imagine a brand new fightergator with ideas like that, jumping off the C-141 in Thailand with a set of flight suits hardly wrinkled by the "anti-G garment," and being welcomed to the world's finest air superiority squadron. They didn't tell us about "designed operational capabilities" (DOC) at RTU. This was a specialized fighter squadron slanted towards air combat training (ACT). I felt there would be a few rides to the range where I could do my thing. Otherwise—well, at least I could find the canopy rails to hang on to.

"New guy school" was a review of certain weapon systems that I really hadn't paid a lot of attention to. The AIM-7 Sparrow radar guided missile could do many things for you if you were good with the radar and if you knew when to employ it. With the pilot intent on chasing little silver airplanes, guess who would get to do those things! Then there's the AIM-9 Sidewinder. Since it's a heat seeker, it works best in the enemy's stern. A good GIB could get you there on radar, even in a hard maneuvering environment. Of course, there's always the possibility that the enemy aircraft will get to your six o'clock position. Then it's up to the pilot to rotate the lethal cone away from the "bandit," with 5+ G's, and for the GIB to pull himself forward and up out of the seat, rotate his head 180°, and keep the attacker in sight. When I was first told this, I thought the instructor was kidding. I soon found out that all he had told me was true.

What is the role of the fightergator in the air combat arena? I'd like to talk about that in the next few paragraphs. Many of the readers are headed to or are already in air superiority fighter squadrons. Still more are assigned to strike squadrons, and we're not so specialized yet that you don't fly ACT. And, for you multi-motor guys, here's a look at a vital part of the Air Force most of us never see. This is one man's view from the rear cockpit of an F-4E. I'm sure other GIBs have other ideas, and those WSOs and NFOs who fly F-111s, F-14s, and F-4Js have still different views.

First and foremost is the equipment. As everyone knows, GIB really means WSO (Weapon Systems Officer) with the emphasis on the "systems." The aspiring fightergator must begin at RTU to master the radar, INS, and even the Weapon Release Computer System (WRCS). The latter is usually a complete mystery to the air superiority GIB, but has many applications in the air-to-air role. Above all, strive to go beyond the "turn on, turn off, write up" stage that may get you through RTU. An in-depth knowledge of these systems will enable you to get the most out of malfunctioning equipment, and being able to

work around a "glitch" may mean the difference between coming home in victory or spending an indeterminate number of years as the guest of an unfriendly foreign power. Knowing the systems thoroughly will enable you to communicate with the specialist responsible for keeping the equipment operational. The end result will be that you and your entire squadron will be flying properly maintained airplanes. That's no small advantage in the very competitive fighter business.

System knowledge is one part of the picture—what you can do with those systems is another matter. Of course every navigator knows about TACAN—simple, easy to use, and not really worth a lot of consideration from an experienced senior navigator like me! I found out I had a lot to learn the first time I had to go from the 240/60 to the 330/90 to find a "bandit," and driving in the 240 and out the 330 doesn't hack it. Knowing the radar is a trick in itself, but the real finesse comes with knowing intercept geometry and being able to apply it to the data on the display. Using all that, you can direct your eager front-seater to the proverbial point in space where he can complete the intercept. And speaking of glitches, how do you launch a Sparrow missile at a guy you can't "lock up"? Before you answer that question, check your training accomplishments for the number of manual track intercepts you logged last half. I suspect many of us aren't as good at that trick as we should be. While we're mentioning intercepts, what is your favorite method of adjusting the geometry? Do you work with the formulas to increase and decrease aspect angle, or do you "double errors," or apply multiples of antenna train angles to your BDHI? Whatever your method, the respected men in the squadron can talk intercepts from any standpoint. The new men in the squadron may not be able to use your method, and the ever-popular TLAR (that looks about right) only works when you've mastered the business to the point where the formulas have become second nature.

All too often, weapon parameters are relegated to the front-seater exclusively. After all, in the final analysis, doesn't he maneuver for the attack? Sure, his trigger is the one that does more than provide a resting place for the index finger, but in the heat of intense maneuvering, you may be the only one who can look around enough to know that the airspeed, altitude, and attitude permit employment of a given weapon. One of the greatest advantages to the two-place fighter is in the second crew member who can be detached enough from the intense air battle to get a glimpse at the big picture.

One of the last skills that comes to the new fightergator is in the area of aircraft performance. This is a tough area to address, so I'll start by noting that most MAJCOM directives encourage acquisition of basic flying skills by the WSO. I was of mixed emotion about this at the outset—after all, said a friend of mine, the professional 'gator really has other things to do besides pulling on the pole. On the other side of the ledger, however, are the words "WSO failed to recognize onset of a dangerous situation," that appear far too frequently in print. Most WSOs find that until they've flown the aircraft a bit, they are often uncomfortable (read "scared") in a maximum performance environment when they needn't be. More important, they are often complacent and happy when they should be screaming at the square jawed fighter pilot up front about airspeed or angle of attack. There will be times when the GIB finds himself running an engagement from the rear cockpit when he has the only visual or radar contact on an attacker. That's when he really needs to understand what the F-4 and the little silver airplane can do, before calling for hard turns, extensions away, and slice-backs to gain the offensive.

I've attempted to set out some first impressions of the air superiority business. USAF Fighter Weapons Review (AFRP 50-4) has published excellent articles that discuss in great detail the precise duties a WSO needs to accomplish in various tactical approaches to air combat engagements. What this article has tried to attack is not those specific duties, but a little of the elusive big picture. That big picture for the F-4 WSO can be covered by one word—attitude. Maybe you'd call it "mental set," but in this air-to-air role, the knowledge discussed in this article is useless without an aggressive, eager attitude. That's important to your career in any AF nav's job, but in the F-4 during air combat training or in actual combat it can mean the difference between coming back to the club for some interesting stories over a cool one, or not coming back at all.

Captain Roger E. Rosenberg is a 1966 distinguished military graduate of George Washington University AFROTC. After NBT, he became a B-52 navigator and radar navigator, instructor at Mather, and was the Executive Officer of the 323rd FTW during 1973-4. He came to his present duty after a tour in the F-4D and E at Udorn RTAFB, Thailand. Captain Rosenberg is presently a career management staff officer at AFMPC, working primarily in WSO manning in PACAF.

THE AWRS NAV SUBSYSTEM

Major Thomas R. ROLL
54 WRS
Anderson AFB Guam

The 53d Weather Reconnaissance Squadron (Hurricane Hunters) (MAC), Keesler AFB, uses a specially equipped WC-130B aircraft for pinpointing the location of major weather systems throughout the Caribbean. The navigation system on this aircraft is designed to provide highly accurate positioning capability, tracking capability, and, in conjunction with the Automatic Data Processing System, precise wind data. The need for precision can be easily understood when looking at a typical hurricane penetration accomplished by a C-130 weather reconnaissance crew. Close crew coordination between pilot, weather officer and navigator is essential in order to locate the storm center. Sometimes, the hurricane is well defined and can be located on the radar scope by virtue of its telltale feeder bands, similar to spokes on a bicycle wheel. More often than not, the eye is located by maximizing right drift from doppler readings, and noting temperature and pressure

Lt Col Avila performs test on AWRS panel.

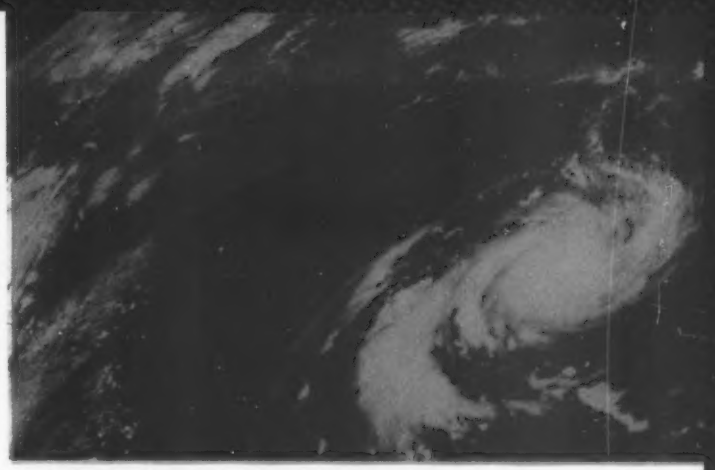
WC-130B.

changes. The beleaguered navigator must rely on the ASN-35 computer for positioning the aircraft and the APN-147 Doppler Radar for wind data. After driving around in the "soup," vectored by hurricane crosswinds and turbulent air currents, the navigator can find himself in the uniquely embarrassing situation of knowing the relative position of the eye of the hurricane, but not the location of the aircraft. Possibly, after reflecting on this sobering thought for a moment, the reader might conclude that a problem just possibly exists. This obvious difficulty invokes an obvious answer; replace obsolete equipment with sophisticated avionics.

The AWRS navigation system consists of a floated inertial platform, the identical platform used in the C-5A Galaxy aircraft, a digital computer, Omega receiver converter, Omega antenna coupler, control indicator, control power supply and the various additional sensor inputs. The system is designed to provide the navigator with a vast amount of data readily requested and displayed on the control indicator. The control routines are relatively simple and the operator is guided by the computer through the proper sequences, normally depressing specific illuminated keyboard buttons. The mode switch on the central panel allows the operator to commence the alignment of the Inertial Measurement Unit (IMU); this process takes approximately thirty minutes. The aircraft must not be moved during this period and electrical power to the IMU must not be interrupted. The basic information required prior to alignment is a correct initial position in terms of latitude and longitude carried to the nearest tenth of a minute. Additionally, the present date and Coordinated Universal Time must be inserted before Omega navigation can be initiated. When the align light on the face of the control indicator panel extinguishes, the system is ready to navigate. The normal mode of operation is Omega-inertial. In

this mode, inertial is updated by frequent Omega positioning. The Omega receiver converter, which measures phase relationships, requires a minimum of three operational Omega stations to provide a two LOP fix. Minimum position accuracy with a good time input and Omega reception is .08 nautical miles. If Omega synchronization is not possible due to an insufficiency of Omega stations transmitting, the computer will automatically degrade the navigation system to inertial only—not exactly a bad way to go. Incidentally, the entire positioning process is completely automated, meaning that you do not have to strain your eyes selecting the proper hyperbola for plotting purposes or adjusting receiver gain to obtain optimum signal strengths; you simply read results in terms of latitude and longitude of present position.

The computer memory will store up to nine waypoints and the operator has the option of selecting track steering which will take him to each point successively and maintain the desired course in between. The navigator may request the true bearing and distance to each of the desired waypoints from his present position. By the same token, he may request the estimated time enroute (ETE) and the estimated time of arrival (ETA) to each waypoint. There are a number of items that can be displayed as desired, e.g., current Coordinated Universal Time, true airspeed, aircraft track, groundspeed, altitude, present position, magnetic variation, heading, et cetera. If the inclination is to record information at a given time, the operator can freeze the present readings but they can be updated immediately at the operator's convenience. The magnetic variation throughout the world is programmed into the computer memory, hence no need exists to add or subtract variation or, for that matter, interpolate values. Another interesting innovation has been the introduction of panel testing for system analysis and troubleshooting. The panel test will evaluate most of the computer-controlled indicators and display the data in hexadecimal format. What this feature purports to do is that upon observing the IMU malfunction light, the navigator may call up a panel diagnostic display to pinpoint the specific cause of the problem. Admittedly, in most cases the purpose of this action would be to assist maintenance personnel to make the necessary repairs when the aircraft returns to the home station. I am afraid the days of "brogan" maintenance and the screw driver adjustment are behind us. However, if the inertial platform has malfunctioned, the computer will select only the Omega input. I suppose the next



The WC-130B routinely penetrates hurricanes such as the one depicted above.

question which comes to mind is, what about that "Blackest of all days" when both Omega and inertial are inoperative? Well, the computer rises to the occasion and selects the dead reckoning mode. In this mode of operation, the aircraft furnishes magnetic heading information via the N-1 compass; true airspeed is supplied by the Automatic Data Processing System and the APN-147 Doppler provides the necessary ground vector information of groundspeed and drift. In effect, then, the aircraft is positioned by very accurate dead reckoning.

In summary, the AWRS navigation subsystem is remarkable from a navigator's standpoint. It offers the capability to provide exacting data necessary for the development of a hurricane model. It is interesting to note that during this system's first operational flight into hurricane Carmen in Fall, 1974, more data was supplied to the National Hurricane Center (Miami) than in all previous flights into all previous hurricanes. The 53d WRS literally "flys the wheels off" of this aircraft during the summer storm months. The optimistic outcome of this summer's efforts is to provide the meteorologist with more precise diagnostic tools for matching wits with the whimsical hurricane ladies.

Major Thomas R. Roll was commissioned in 1960 through OTS. He attended UNT at Harlingen AFB, Texas and NBT at Mather AFB, CA. He has 7600 flying hours in multi-engine aircraft, served as an instructor in five commands and flight examiner in two. Additionally, he served as a platform instructor at the USAF Academy. He is presently assigned to the 54 WRS at Anderson AFB, Guam. His additional duties include Squadron Executive Officer and Air Force SAR Liaison Officer.

The Navigator / An Inflight Commander

Captain Michael A. NIZIOL
456 BMW
Beale AFB CA

A navigator's job is a full time one, from the takeoff roll to the full stop landing. No matter if it is an hour and a half mission for a GIB (guy in back) in an F-4, or a 24 hour Giant Lance B-52 bomber mission, it involves not only work but continual decision making by the navigator.

The minute takeoff roll starts, a major factor of leadership quickly emerges—the need and ability to make timely, thoughtout, and often spot decisions. The navigator must weight many variables; constantly changing winds, aircraft malfunctions, weather, site closures, and failure of navigation equipment. Then there are the alternatives to consider: needed required items, fellow crew members training needs, timing to critical points, ARTCC, and the ability to accomplish a professional job of navigation.

Some people do have an intuitive knack for leadership, others who have the capability, learn it. The navigator has the golden opportunity to often face the major challenges of leadership-the often occurring event of being "put on the spot" requiring a NOW decision. A true leader doesn't shun these opportunities. He accepts them as a reality, cultivating and storing the knowledge and expertise gained through them.

So far, I've mentioned that a leader is one who can face the need to make a decision, weigh the alternatives in the time allowed, and produce reliable results. Let's look at some of the finer intangible points of leadership and some inhibiting flaws. Positively asserting yourself and your navigational decisions definitely affects the response you get from your fellow crew members. How many times have we all heard or been guilty of directions like: "Well, let's see...," "Let's try about x degrees left or right...," "I'm not sure, but...," "Maybe we should..."? These indecisive terms offer little assurance that you the navigator are "on top of everything." Being positive and affirmative expresses your own level of confidence and lets the crew know that you have a handle on the situation. If you don't know the validity or legality of an action you are pondering, SAY SO, for you are part of a crew, and a crew works together. Being honest in a state of indecision also reflects a quality of integrity about you. Add to all this a command voice, and you will really be getting it all together.

A navigator's level of responsibility for a successful mission often exceeds the responsibility of other crew members. Because of this level of responsibility, it is imperative that you the navigator assume and assert the command authority that is given to you by mission requirements. Your aircraft commander may be called on the carpet, but YOU have to explain why YOU missed the end celestial nav point, why YOU missed the low level entry time, and why YOU couldn't hit the targets because YOU were late.

A good leader accomplishes his own job with precision and is the keystone to building an effective team of crew members. Mistakes are made by each of us, and many of them are repeated more than once. Such is the life of the new inexperienced navigator. Time brings to our sphere of experience many techniques which help each navigator reduce time expended at his job. Here I'm talking about cutting corners and expended effort. That doesn't sound very professional, but if you look at it realistically, it really is professional. For example, have you ever noticed the obvious difference in time expended in flight planning between a new navigator and an "old head?" The experienced navigator finds that by using short cuts and time saving techniques, he is able to do his work rapidly and accurately. Basics are fine for starters and are needed for a strong foundation of knowledge about navigation, but advancement to a more precise and less cumbersome method is really expected as the experience level rises.

Rules were made to help you to fly safely and productively, but good air sense is also required to do a good job. Mere minute to minute inflight survival as a viable leader-type navigator doesn't allow you the chance to stay ahead of the airplane. We all have heard that "the more you do on the ground before flight, the easier the time inflight." That is a truism, but mostly for a flight that goes as planned. What about some of those BIG inflight changes? Here come the elephants and ants. This is an exposure to crisis management or crisis leadership—a true test of your on-the-spot decision-making ability. But, more important, the crisis will reflect your preparation for major inflight changes with a planned canned backup to be plugged in when needed. If you have it altogether, the pilots can't beat you to the punch with their suggestions as to what to do. Nothing sounds greater than to hear the navigator say, "I have it pilot and here it is," within a few short minutes after the change. You have just bumped off an elephant, and are getting ready to stomp the ants. You have banished from your mind the threatening picture of the chief navigator of your wing or squadron "calling you on the carpet" for making an error.

We have seen that on the ground and inflight, a navigator exercises the functions of leadership by planning, organizing, directing, coordinating, controlling, deciding, and innovating to name just a few. His leadership ability is enhanced by assertiveness, positiveness, integrity, and, literally a "gung ho" attitude. The navigator of today, with his numerous opportunities to practice leadership, is in a good position to be the wing commander of tomorrow.

The Air Force belongs to the navigators, too, and they will play a major role in charting its future course. Practice leading today, and tomorrow will be your time to stand in front and say, "Follow Me."

Captain Michael A. Niziol is a 1969 graduate of the U. of Detroit. While a student, he distinguished himself as the recipient of the University Presidents Award for performance as an Air Force ROTC Cadet Corps Commander. Capt. Niziol is a 1972 graduate of both UNT and NBT. He upgraded to B-52 instructor navigator in 1974 and radar navigator in 1975. He has a Masters degree in Business Administration and has completed SOS and ACSC by correspondence.

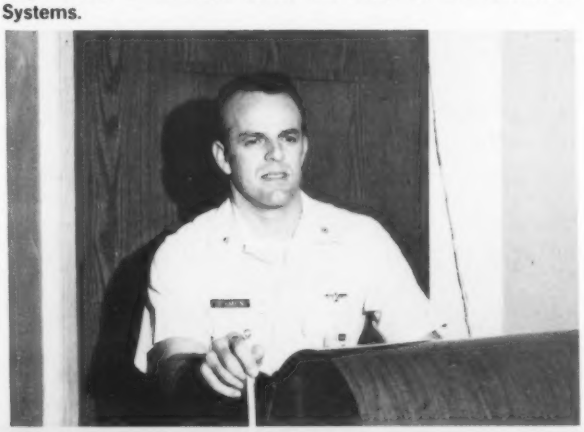
Electronic Warfare Refresher Training
Or
"Who Says You Can't Teach An Old Crow New Tricks?"

Captain James W. BOSWELL
Directorate of Doctrine
Headquarters USAF
Washington DC

Once every two months a Matherite might notice a group of rather "mature" students entering the 453d Flying Training Squadron. These 10 to 16 officers ranging in rank from captain to colonel are on base to attend Electronic Warfare Refresher Training (EWRT). EWRT is a five day course designed to inform Electronic Warfare Officers (EWOs) of current developments in their field. A less obvious purpose is to provide a forum for the interchange of information between those working in electronic warfare and related fields.

The first myth to dispel is that all attendees are EWOs. A recent class of 13 consisted of nine EWOs, three pilots, and one nonrated officer. All 13 shared a common bond—they are working in areas requiring consideration of electronic warfare. Thus, the student might be a nonrated captain doing research and development at the Air Force Avionics Laboratory, a colonel working in Operations Plans at the Air Staff, or one of the 1,500 line EWOs throughout the Air Force.

Major Peter E. Sfameni: briefs the class on B-1 Defensive Systems.



EWRT class 76-05

Since EWOs do form the majority of each class, the first question they raise is, "How has Mather changed since I was here as a second lieutenant?" Early in the week the EWRT team briefs the class on navigator training programs, including Undergraduate Navigator Training (UNT), Navigator Bombardier Training (NBT), and Electronic Warfare Training (EWT) programs.

Telling is only half the story as there are tours of the T-43 navigator training aircraft, T45 navigation simulator, T4 penetration simulator, and the new ALQ-T5 simulator for electronic warfare training (SEWT). An EWO from Security Service recently commented, after touring a T-43, "Simply unbelievable, a training aircraft that's abreast of, and in some cases ahead of, the operational arena." The Wild Weasel types from George AFB really do enjoy getting their hands on the Weasel gear in the SEWT.

EWRT is taught in a seminar format. The tone of the course is set by Colonel Leo D. O'Halloran, Jr., Deputy Commander for Operations at Mather, and Captain Larry N. BJorn, EWRT Flight Commander. They stress that the benefit gained from the course is not only what will be learned from the platform instructor but also the interchange of information between attendees. The payoff is when the EWO working with Drones at Davis-Monthan finds an area of interest shared by the EWO assigned to Headquarters SAC. Or, perhaps it's the EWO in a MAC wing (yes they have them) finding someone with "just the information I need for a hot briefing."

Although EWRT is a formal AFM 50-5 course, the instructors attempt to "tailor" the course to meet the needs and desires of each class. In addition to the scheduled blocks of instruction, there are several guest lecturers during the week. These are class members or outside experts brought in to brief the class. The subject matter concerns an aspect of electronic warfare in which each man works. This aids in the all important exchange of ideas and material.

We in the Air Force do not have all the answers to the use and employment of electronic warfare. Two extensive presentations acquaint the class with the problems faced by, and cooperation available from, our sister services. The speakers are an Army EWO from the Army Air Defense School at Fort Bliss and a Navy EWO from the Fleet Combat Direction Systems Training Center at San Diego. These presentations never fail to be eye-openers to those who have developed "tunnel vision" concerning Air Force electronic warfare uses and problems.

During EWRT week, attendees are encouraged to meet with the Basic Course Electronic Warfare students. This is an excellent chance for the young lieutenant, who may have been in training at Mather well over a year, to meet and converse with a "real Air Force" EWO. Early this year a student two weeks from graduation was able to meet his Wing EWO, six months and 2,000 miles in advance.

EWRT is a busy five days. The interchange is continuous. The formal blocks cover such topics as electronic warfare organization, hostile air defense systems, new developments in ECM and ESM, and electro-optics. You will find the EWO from TAC headquarters trading information with the EWO from ADC headquarters. The interchange of ideas is invaluable. The real payoff probably occurs six months or a year later when the EWO flying F-4s at Homestead has a problem, reaches down and pulls his EWRT class roster out, and calls the EWO at George, Nellis, Shaw, the Pentagon, Eglin, Wurtsmith, or Edwards who was in EWRT with him at Mather. Providing a forum for such an interchange and further contact is what the members of the EWRT team at Mather see as their primary mission.

Captain James W. Boswell was commissioned via ROTC at Texas A&M, 1968. He graduated from EWT in 1969. His first assignment was to the EC-121R at Korat RTAFB, Thailand. He flew in B-52s at Carswell AFB, Texas, from 1971 to 1973. His next assignment was as an EWT instructor at Mather. This past year, Capt Boswell has been assigned to the Pentagon as an Air Staff Action Officer via the ASTRA program.

Window to the world: EVS and the navigator

1st Lt James R. McDONALD
60 BMS
Seymour Johnson AFB NC

In the small dark compartment, surrounded by the glow of red lights illuminating instrument panels and digital computer readouts, sit two men. Their only contact with the world outside is a radio and their instruments. Where are these men working—a command post, a missile silo? No, they're the B-52 navigator and radar navigator.

The job of the B-52 navigator team isn't really as isolated as it sounds. Until recently they depended almost totally on radar, the bombing-navigation system (BNS) computer, and dead reckoning for information about the outside world. With the continuing modification of the B-52 "G" and "H" models with the Electro-Optical Viewing System (EVS), these navigators will have a "window to the world."

The EVS is designed to augment the B-52 in its mission profile by providing improved Terrain Avoidance (TA), a VFR capability while in the closed curtain environment of a nuclear war, and infrared avoidance of nuclear fire balls. The system also provides for greater safety, as though four pairs of eyes were outside the cockpit during critical phases of flight. Though the system is designed mainly for use at low level, EVS can be an aid at high level for air refueling, cell formation, weather avoidance and fixing.

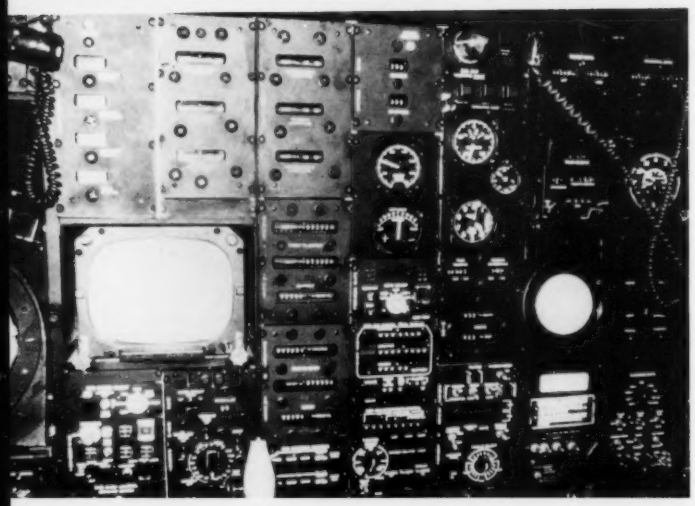
The EVS system is comprised of a steerable television (STV) camera and a forward looking infrared (FLIR) sensor. These send images through the data presentation group which ties-in aircraft and BNS information, to the four monitors located at the pilot, co-pilot, navigator, and radar navigator stations. The sensors are mounted in turrets located behind the nose radome. The turrets allow the STV and FLIR to swing through 90° of azimuth (45° each side of system centerline) and 60° of altitude (15° above and 45° below system horizon). The movement of the camera sensor can be controlled either by the pilot or by the navigators using either the BNS (the sensor "looks" where the BNS crosshairs are) or manually with the BNS tracking handle, through the full range of azimuth and altitude. The pilot has primary control over the steering and can take command of either sensor at any time.

The video produced by the STV is very much like a good black and white television picture. The FLIR uses the infrared radiation given off by an object, producing a "negative" picture—the reverse of the STV. The FLIR, though not as sharp and bright as STV, has advantages in range and is better in weather. Both systems are limited in clouds or heavy fog. The FLIR video can be "switched" to produce an STV-type image using the FLIR Reversal mode.

All three video modes are controlled at each monitor allowing the navigator to watch FLIR, the radar navigator FLIR reversal, and the pilots STV. Along with the video there is other information displayed on each monitor. A digital time-to-go (TG) readout is displayed, as well as the azimuth and altitude of the sensor being viewed. Indicated airspeed and absolute altitude between 0 and 3000 are shown. A heading reference using either the BNS FCI (Flight Command Indicator) or the pilot's heading "bug," along with a set of fiducial marks indicating the center of the sensor's field of view also appears. Information concerning the aircraft and a TA trace is found on the pilot's monitor.

The EVS is designed to be used from taxi-out until taxi-back, and throughout all phases of flight. On a normal training mission the B-52 crew flies air refueling, a SRAM programming leg and/or celestial navigation leg, a low-level profile including TA and bombing, and several penetrations and approaches. The navigation team can make good use of the EVS during all these periods of flight.

Stowed STV and FLIR turrets on B-52.



EVS display at RN station.

For aerial refueling and cell formation, the EVS supplies the crew with a visual means of monitoring the position of a tanker or other aircraft in a cell. Using the FLIR mode, which can "see" farther (15 to 20 nm) in daylight and light haze than STV, the radar navigator can give accurate visual ranges and headings during the air refueling rendezvous. EVS is most effective at ranges of 4nm to 1/2nm behind another aircraft. In a moderate haze, the FLIR can usually pick up the tanker or other aircraft by engine exhaust, well before the pilots make visual contact.

At high altitude the EVS provides an excellent means of fixing, and it can be especially helpful in SRAM programming. With SRAM we use an inertial navigation computer which, when given precise fix data can calculate the B-52 position to within 600 feet. To obtain such accuracy, small, precise radar returns are used in conjunction with the BNS ranging capabilities. SRAM fix points could be a factory in a small town or the end of a bridge. Using the fiducial mark, and the "zoom" capability of the EVS system (both sensors can "zoom" in on the center one-third of their field of view) the crosshairs can be placed directly on the specific factory or the exact end of the bridge. Also, because of the range of the EVS (on a clear day, looking toward the ground, it is in excess of 20nm) the fix points can sometimes be seen before a good radar picture can be obtained, making EVS the primary fixing tool.

EVS is used for low-level penetration and terrain avoidance navigation. The pilots have control of both sensors for low-level, using them for TA and hazard avoidance. The sensors usually are aimed along the ground track, providing good visual coverage of the low level route during low altitude flight. The heading reference is kept in BNS. The navigation team, along with navigating, can help visually clear the aircraft of hazards using EVS. The absolute altimeter also provides the navigators with another safety check on aircraft altitude.

Bombing with EVS introduces a new aspect to the old problem of getting the bomb on the target. No matter what the equipment, all bomb runs start the same—as a time and a heading to the target. Once established on heading, the BNS automatic functions are used along with radar scope interpretation to find and identify the target(s) to be bombed. After identification, the BNS crosshairs are placed on the target by radar and the bomb run checklist is accomplished. At approximately 180 seconds until bombs away (180 TG), the navigator checks that he has control of the sensors. He then attempts to visually find the target while the radar navigator continues to refine his crosshair placement using his radar scope. It's not until 60 TG that the radar navigator makes the transition from radar scope to EVS monitor. Usually the navigator will have identified the target visually and can aid the radar navigator in target acquisition. Since the crosshairs are on the target, it should be within the fiducial marks, i.e., the center of the STV field of view. The radar navigator then finishes the run using primarily the radar, with the EVS narrow-field-of-view as an excellent backup aid.

If low-level is the major use of EVS, then safety is the major benefit. One becomes acutely aware of this in the penetration and approach work at the end of the mission. Using the EVS readouts of absolute altitude and indicated airspeed, along with the video, the navigation teams become better equipped safety observers during approaches. EVS also supplies two more pairs of eyes to watch for other aircraft and possible high obstructions.

The procedures discussed above are just a few made possible by the EVS modification. As more units receive the system, each squadron will be able to find new procedures for it. The B-52 has always been an awesome deterrent weapon and now with the EVS, the aircraft becomes even better equipped to perform the SAC mission.

1Lt James R. McDonald is a radar navigator on the B-52G. Lieutenant McDonald graduated from the University of California at Irvine in 1972. He entered OTS in November of that year and received his commission in February 1973. He graduated from NBT in early 1974. Lieutenant McDonald is a member of one of SAC's "mini" nav teams which report to their units with both a navigator and radar navigator.

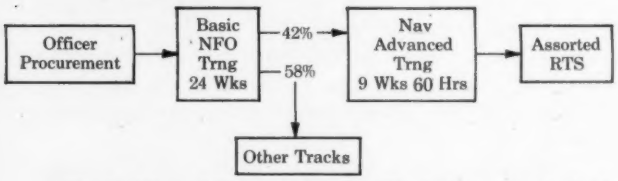
Interservice Navigator Training at **mather**

Captain Hector M. ACOSTA
323 FTW/DOTCU
Mather AFB CA

On 24 September 1975, the Interservice Training Organization (ITRO), Navigator Subcommittee, Flying Training Committee, published its final report on an in depth study of interservice navigator training. Prior to this report, preliminary investigations dating from mid-1974 had indicated that "...there was a potential for consolidation of the Air Force Undergraduate Navigator Training and the Navigator sub-course of the Naval Flight Officer (NFO) Training Program. This could be accomplished in the near term without requiring a major policy change in training concepts and philosophy by either service."

The key difference in training philosophies between the two services deals specifically with the Universally Assignable Navigator (USAF) versus the Tracking Concept of training (USN). From the onset "areas of commonality" and "cost-effectiveness" became the by-words. By focusing on the "core" general navigation courses in Undergraduate Navigator Training at Mather, the resulting plan could provide the Navy with a state of the art, "trackable" NFO and save DOD a great deal of money.

The simplified flow for the NAV/NFO in the Navy program is:

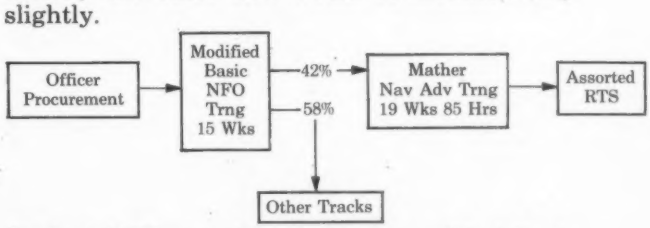


Basic Naval Flight Officer Training, located at NAS Pensacola, is a 24-week course in the fundamentals of Naval airmanship examining briefly:
Flight Procedures, Flight Rules and Regulations, Operating Principles of Basic and Advanced Navigation Equipment, Communications Systems, Meteorology, and introductory information about Naval Flight Organization and Procedures. Graduates are identified for tracking to one of four possible advanced schools: RIO, Radar Intercept Officer Training (Fighter Gators); AJN, Advanced Jet Nav Training (Attack Gators); ATDS, Airborne Tactical Data Systems Training (AWACS-Gators); and Nav Training (Navigators).

Approximately 42% of the graduates from the Basic NFO course (approximately 200 student NFO's per year) proceed to the NAV advanced school for navigator training. The NAV school is located at NAS Corpus Christi, Texas, and uses the T-29 as its primary flight training platform–shades of yesterday at Mather.

The duration of this course is nine weeks, with 60 flying hours programmed. Upon successful completion of the NAV advanced school, the student NFO is awarded his wings, "Designated" as a NFO (equivalent to USAF "Rated"). He then moves on, more or less directly, to his RTS, Replacement Training Squadron. The RTS is roughly a Navy equivalent to an Air Force RTU providing "aircraft-specific" training prior to operational deployment.

Under the planned Interservice Training activity the basic flow would be modified only slightly.



Student NFOs would complete a modified Basic NFO course of approximately 15 weeks at Pensacola NAS. They would then come to Mather and be integrated into one of our UNT squadrons. A two week "Lead-in Course" would consist of the normal orientation-indoctrination training received by UNT students plus blocks of instruction selected to place them on an equal experience basis with their Air Force UNT navigator trainee counterparts. The proposed Lead-in course includes portions of: Career Planning, Airmanship, Advanced Airmanship, and Weather blocks of instruction which cover specific Air Force forms and procedures used during Mather training.

The Lead-in course would be time phased, so that, at its completion, the student NFOs would join a specific UNT class on their UNT training day 30, the beginning of the Navigation Procedures Phase. From this point through the end of the Global Phase the NFO students would receive their training alongside their UNT counterparts for the "core" of Undergraduate Navigator Training. At the end of the Global Phase, the student NFOs will take a one week course to help prepare them for their upcoming assignments. Graduation, of course, will be marked by the awarding of wings (gold) and "designation" as Naval Flight Officers. Upon

graduation these future NFOs would have completed 96 training days, 85 T-43 flight hours and 64 T45 simulator hours at Mather AFB. Approximately 10% of them would be assigned to "Special Missions" aircraft in support of research, search and rescue, reconnaissance and other miscellaneous activities. The remaining 90% of the fledgling Naval Flight Officers would depart Mather bound for VP squadrons (RTS) for about 15 weeks of training in the P-3 Weapons System prior to operational deployment.

The P-3 is a sophisticated Anti-submarine Warfare weapons system featuring an ASQ 114 digital computer, complex specialized sensor equipment, dual inertial systems, OMEGA, doppler, and radar with sensor and enroute navigation functions. The P-3 Communication System is also impressive with dual HF, dual UHF, and Data Link capability. In addition to the above "hunter" capacity, the P-3 is a formidable weapons delivery platform for her "killer" function.

Two primary theaters of operation exist for the P-3: West Coast (Pacific deployment), RTS at VP-31, NAS Moffett Field, California; and East Coast (Atlantic deployment), RTS at VP-30, NAS Jacksonville, Florida. Under this proposed training future NFOs out of Mather would be distributed approximately 50-50 between the East and West Coasts, dependent upon operational requirements.

Since mid-1975 a myriad of agencies have been directly involved in preparations, laying the groundwork for Interservice Training at Mather. Facilities preparation, administrative support, details of student administration, and adjustments to training flows have all required constant review, reassessment, and coordination up, down, and across service chains of command through the Joint Chiefs and the Secretary of Defense.

Program Action Directives (ATC and Local), Interservice Support Agreements (ISSA's), Memorandums of Understanding, and specifics detailing *who gets how many* of *what* form and *when* are still being staffed, negotiated and implemented. To supplement Air Force manning in this interservice program the Navy would provide approximately 12 instructors for integration into the UNT squadrons. For administrative support "Navy Style", a cadre consisting of three officers and four enlisted personnel would constitute the Naval Air Training Unit (NATRAU). Upon implementation, NATRAU's commanding officer would fill an 0-5 billet with an 0-4 assistant, and an 0-3 Administrative Officer. NATRAU will provide a vital link for administrative and liaison activities between the two services, with offices in Bldg 3875, home of the 449th Flying Training Squadron.

Another possibility, to coincide with the NFO training at Mather and follow the same training profile, would be future training of about a dozen United States Coast Guard Pilots per year in the art of navigation. They would be administratively assigned to their respective UNT squadrons and participate in all normal navigator training activities.

While a plethora of details are still being pounded into shape at this printing, Mather is looking forward to a rewarding experience in interservice training The opportunity to expand horizons of experience, to learn and share knowledge with several sister services toward a mutual end of navigator training, will hopefully prove invaluable in future such endeavors. We heard an example of expanding horizons in a recent conversation, as a USAF CE Representative queried, "As I read this diagram you want this floor-to-ceiling partition about here?" The USN Representative answered "That's affirmative. That deck-to-overhead bulkhead about there!"

Interservice cooperation to streamline training and reduce operational costs and to avoid wasted effort and expensive duplication of hardware can often be a highly effective management technique for the Armed Forces to employ in the best interest of the people and future of the United States.

Shake the stick, we've got it!

Captain Hector M. Acosta is a graduate of St. Mary's University, San Antonio, Texas. Following navigator training and RTU at Shaw AFB, South Carolina in the RF-4C, he was stationed at Udorn RTAFB, Thailand. On his 98th combat mission, he was shot down and subsequently interned in North Vietnam. After repatriation in 1973, he was assigned to Mather AFB as a Squadron Instructor. Since November 1975, Captain Acosta has been a project officer for interservice training at Mather AFB.

THE MARINES ARE LOOKING FOR A FEW GOOD NAVIGATORS

Captain Daniel O. PYNE
323 FTW/DOTCP
Mather AFB CA

As the recruiting posters say: "The Marines are looking for a few good men." Presently, though, the phrase should continue: "...to go to California to learn aerial navigation." Beginning in July of this year the Marines will arrive at Mather Air Force Base to begin training navigators in an all new program. The once lone bastion of Air Force navigation will now share its facilities with the Navy, Coast Guard, and the Marine Aerial Navigation School (MANS). Unlike the Navy and the Coast Guard navigator programs which may be integrated into the existing Air Force Undergraduate Navigator Training Program, the Marine Corps' Aerial Navigation School will be operating as a separate organization at Mather AFB. The only contact the Marine school will have with the Air Force program will be the sharing of the sophisticated Air Force facilities—the T-43A aircraft, the T45 simulator, the Navigation Procedures Laboratory, the Planetarium, and the Learning Center.

Coming to Mather AFB has been a major step for MANS since its inception some 34 years ago. Aerial navigation training for the Marine Corps first began in 1942 when five Marine officers were assigned to the Weems School of Navigation in Annapolis, Maryland. After completing this course, these five officers became the nucleus who established the navigation school at Camp Kearney, Mesa, California. A year later, the Marines were on the move again, this time to Marine Corps Air Station (MCAS) Cherry Point, North Carolina, where they graduated their first class of navigators in January 1945. However, this training program existed only as a ground school with the school finally being disbanded in March 1948.

In March 1952, after the beginning of the Korean conflict, the Aerial Navigation School was reactivated as part of the Airborne Operator Schools (AOS), then located at Cherry Point, North Carolina. The AOS consisted of the Aerial Navigation School, the Radio Operator School, and the Electronic Countermeasure (ECM) School. During this time, Marine navigators trained in such aircraft as C-54s, R4D-6s (C-47B), and R4D-8s (Super DC-3). The Aerial Navigation School remained at Cherry Point until January 1971, at which time it was moved to Naval Air Station (NAS) Pensacola, Florida, when the Navy assumed responsibility for the flight support. A detachment, VT-29, of T-29 aircraft from NAS Corpus Christi which had been previously assigned for Navy support, now provided flight support for the Aerial Navigation School at Pensacola. At this point, the name of the school was changed to the Marine Aerial Navigation School (MANS). After two years at Pensacola, the Navy

Marine navigator hard at work.

moved the detachment of T-29s and the Marine school moved to NAS Corpus Christi in order to continue the T-29 flight support. Finally, due to the phasing out of the T-29s at Corpus Christi, the Marines have turned to the Air Force and Mather AFB for help.

Marine KC-130.

The first class of the MANS program is scheduled to begin on 15 July 1976. In many areas, the MANS program will be similar to the present Undergraduate Navigator Training (UNT) program. It will concentrate on basic dead reckoning navigation using radar, celestial, pressure differential, and Loran navigation procedures. Unlike the UNT program, the Marine student navigator will not be taught grid or low level navigation procedures. The entire program is expected to take approximately 24 weeks as contrasted to the present 28 week UNT program. The makeup of the school itself is very different from that of the Air Force's navigator training school. The annual school input is four student classes per year, with an average of 11 students per class. The students are enlisted personnel ranging from E-1 to E-6. Likewise, the school is administered by nine Marine noncommissioned officers in the rank of E-5 to E-9 (Sergeant to Master Gunnery Sergeant). The present director of the Marine Aerial Navigation School is Warrant Officer William E. Claussen, USMC.

The smooth transfer of MANS to Mather is being handled by a team of Air Force navigators from the 323d Flying Training Wing at Mather AFB and Marines from Corpus Christi. It is this team that has been established to assist MANS in adapting their T-29 training program to this new and sophisticated training environment. Under the direction of Major John E. Merchant, this team is developing a highly efficient and cost-effective navigator program for the Marine Corps. The MANS program, like many Department of Defense training programs, is being developed through the systems approach to learning. This program is being designed to train a navigator for the Marine aerial refueler, the KC-130 F/R. Marine Corps navigators are primarily assigned to this aircraft, which closely resembles the Air Force's C-130 except for the refueling pods attached to the wings. Its primary mission is the refueling of both Marine and Navy fighter and attack aircraft. However, like its Air Force airlift counterpart, the C-130, it may also be used for intratheater combat support. The navigator's station in the KC-130 is similar to that of the C-130. Looking at the position one would recognize the APN-59 radar, the SCR-718 radio altimeter, the APN-70 loran and the periscopic sextant. Except for a few KC-130 aircraft which are equipped with inertial navigation, the KC-130 does not have a doppler or a navigation computer system as does the Air Force C-130.

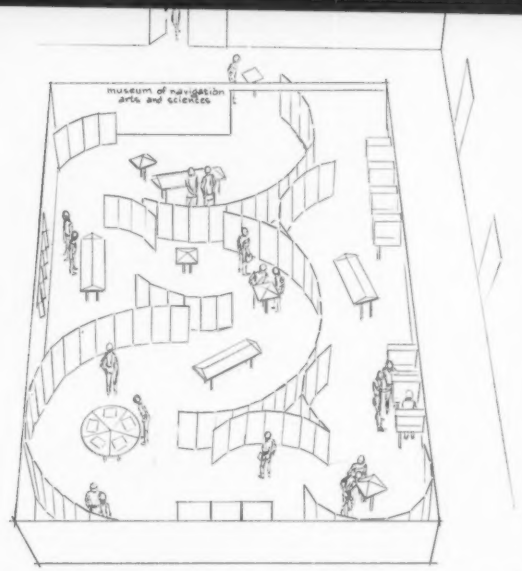
MANS supplies all of the navigators for the three active duty Marine KC-130 squadrons. Presently there are approximately 60 Marine navigators assigned to KC-130s. These squadrons are located at MCAS Cherry Point,North Carolina (VMGR 252), MCAS El Toro, California (VMGR 352), and MCAS Futema, Okinawa (VMGR 152).

Over the years this small Marine school has furnished navigators for aircraft such as the R5-C (C-46), R4D(C-47), PB4Y-2(single tail B-24),PBJ (B-25), R4Q (C-119), R5D (C-54), and the present KC-130. The navigation school has gone from strictly a ground school environment during World War II to the present sophisticated training program. Today signals a major step forward for MANS, for the Marines have landed at Mather and the Air Force welcomes these few good men.

Captain Daniel O. Pyne is a 1967 AFROTC graduate of the University of Maryland. He has flown as a navigator on the KC-135A and as an instructor on the C-130E. He taught Navigation Procedures in the 451 FTS at Mather AFB, California, prior to his present appointment. Capt Pyne is presently assigned as a program developer for the USMC Navigation Program. His awards include two DFCs and four Air Medals.

PROJECT MUSEUM: A First Status Report

Captain James P. MALLERY
450 FTS
Mather AFB CA



To be or not to be, that is the question. I am referring, specifically, to a Museum of Navigation Arts and Sciences.

As a student officer at Mather, I remember a small trophy case of sextants and computers displayed in Bleckley Hall. When I came back as an instructor some five years later the trophy case was missing. It seems that I was not the only one interested in navigation memorabilia.

In September of 1975, the Wing Commander, Colonel Sullivan, and his staff decided that the concept of a museum should be pursued. I briefed the wing staff in December on the possibilities of establishing such a project. It was then designated as a Base Bicentennial Project.

The Deputy Commander for Operations, Colonel O'Halloran, then opened up a room in Bleckley Hall to gather, catalogue, and display any available items pertaining to navigation or base history. In a few short months we found that the room was not large enough. The wing staff was then approached, and the decision was made to relocate in the old Flight Simulator Building (Sizemore Hall—remember the T10s?).

There now is a T-29C (s/n 53-3439) on permanent static display next to the Mission Briefing Building, and a T10 "K" radar simulator in operating condition is on permanent display in Sizemore Hall. Most of the items formerly displayed in Bleckley Hall have been recovered. A sizable DR and celestial computer collection have been added, along with a small but representative number of aviation sextants and octants from both the Navy and Air Force.

Mather has been in existence since 1918. During this time period such famous aviators as Lemay, Arnold, Spaatz, and Rickenbacker have passed through its gates. For over 30 years, Mather has been involved in the training of navigators. With this heritage, Mather is certainly an appropriate location to exhibit a panorama of the field of Navigation Arts and Sciences to the aviation community and the general public.

Interestingly enough, the need was established when I asked a recent UNT/NBT graduate: "What is a driftmeter?" Now most of us would close our eyes and remember the "K" factors from 51-40 Vol III, and perhaps even the famous "war story" of the Overland South Night Celestial Check mission—Dubhe, Deneb and yes Delano—using relative bearing and the trail angle. His answer was a bit of a surprise: "I guess that is the needle above the groundspeed meter on the doppler." In less than six months time, we've developed a generation gap. The Landfall is a new hairpiece for women, and the noon time fix is impossible unless you have a TACAN.

Here is our chance to preserve the profession. If this is to be accomplished we need to record and display a collection, representative of the role Navigation has played, and continues to play, in aeronautical history. As such, we must actively involve all interested navigators in this collection of information, artifacts, and memorabilia, to preserve our past and make an historic statement for the future.

On 9 April 1976, we inaugurated our first public display. We are looking at the fall of 1976 for completion of the major collection projects. For information concerning this project, please contact us at AUTOVON 828-2177 or write THE NAVIGATOR Magazine.

Editor's Note: A proposal to establish the museum as an official part of the Air Force museum system is being prepared.

Captain James P. Mallery is a graduate of Westmont College, Santa Barbara, California. While at Westmont he majored in Social Science. He graduated from UNT in August, 1970. His first assignment was to KC-135s. From there he went to SEA in the EC-47Q. While in SEA he earned a DFC and an AM with four OLCs. Captain Mallery is presently an instructor at Mather.

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